Concept - constant growth ends in demands for complex learning that far exceed our natural learning capacity.

THE INFINITE SOCIETY

- A GUIDE TO GROWTH INDUCED COLLAPSE -

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ABSTRACT

Even under the condition of totally unlimited earth resources, an unlimited additional work population capable of work without consumption, and complete faith in institutions, exponential growth fails very shortly after the initiation of the crisis sequence. Based upon the inherent character of technological progress, it is demonstrated rigorously that the rate at which failure crises appear becomes greater than the rate of growth. It is also demonstrated that the net effect of technological advance is to delay the appearance of crises for a short time and make them worse when they come. Reasons why both common understanding and traditional economic analysis fail to make these same predictions are suggested, along with some ways to interpret a bleak picture as a hopeful opportunity.

INTRODUCTION

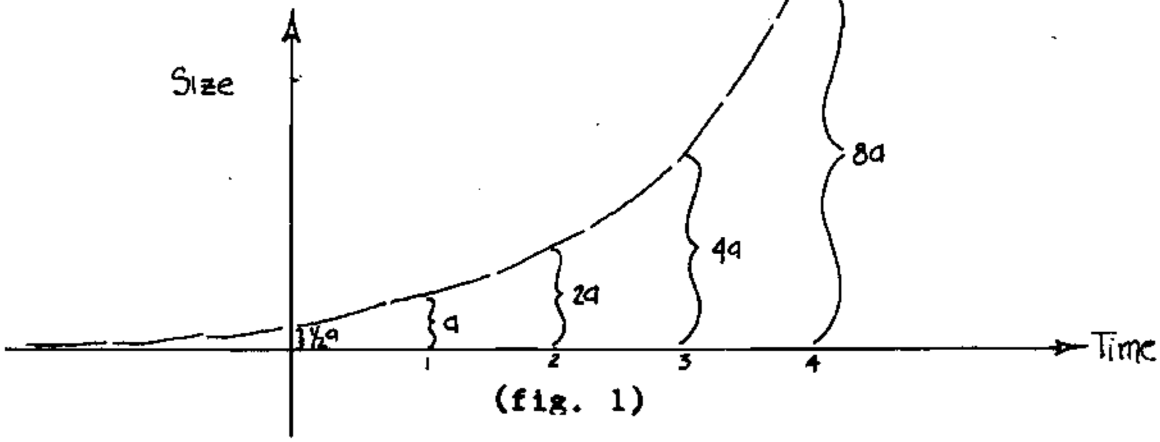
The following analysis depends upon the thorough understanding of three basic concepts: exponential growth, technological refinement, and crises. The stimulus for the consideration of these three concepts together is that they allow conclusive predictions regarding our growth process, without needing to consider any of the particular boundary conditions, i.e. the often named but easily disputed limits of growth. I assume that the earth is unlimited, that population, beyond our own, capable of work without consumption, is unlimited, and faith in institutions is unbending.

1. EXPONENTIAL GROWTH

When something grows by doubling in a constant time period, it is called exponential growth. The inventor of the game of chess asked to be paid one grain of wheat on the first square of the board and twice as much on each succeeding square as on the one before. The King, of course, because he liked his new game and wasn't too thoughtful, agreed to the unusual formula. Thus he began to pay 1+2+4 grains +8+32+64+128+256+512+1024+2048+4096+9192+18,384+36,768+73,536 and he had only gotten through the first two rows of the chess board. He began to worry, the inventor laughed and all was over. The overwhelming power of this doubling process is that on each aquare <u>more</u> grains are required <u>than on all preceecing squares combined</u>.

Exponential growth occurs in nature but only in very special places, since it is such stupendously powerful stuff. In the womb the first cell of a new life becomes a million cells in very short order but then the cells stop the doubling growth and a new kind of growth begins. In a cut in the skin, neighboring cells 'turn on' and start doubling, when the gap is filled they 'turn off'. In a cancer, the cells keep doubling. One good definition of cancer is that it is an organism who's criterion for health is the continued presence of exponential growth.

Our economic system has such a criterion for health. It is that unless we grow at 4% (or so) each year, that we are unhealthy. The doubling time which corresponds to 4% per year is 17.3 years. The common excuse for accepting a definition of health for our economic system like the definition of health for a cancer is that scientific discovery is unpredictable yet certain, and will forever push the limits of growth higher and faster than the growth itself. The fault in this statement lies in our way of perceiving our distance from the limits, but that's getting ahead. An exponential growth curve looks like this.

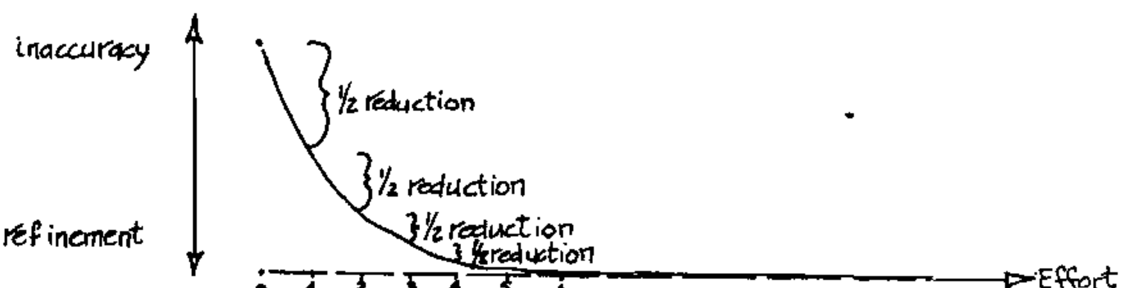


(fig. 1)

<u>The overwhelming power of exponential growth of consumption is that in each doubling period, more is consumed than the total of all past consumption</u>.

2. TECHNOLOGICAL REFINEMENT

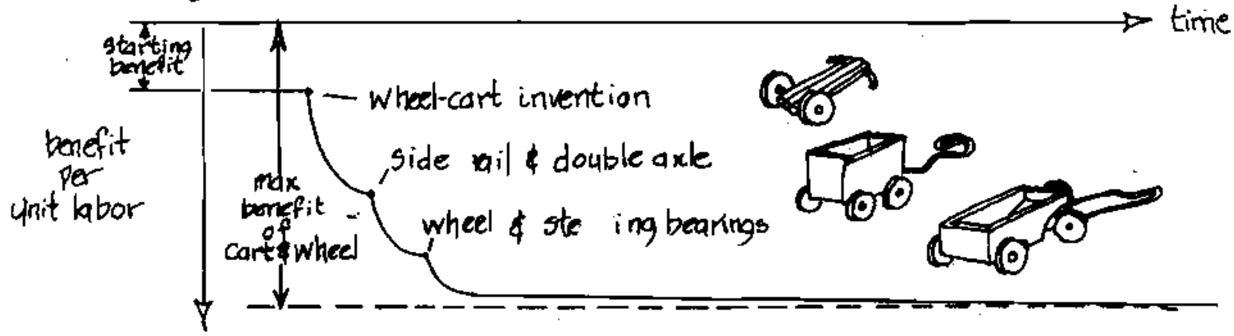
Nothing is ever exact. Making things closer and closer to being exact is hard work. In general it requires an equal amount of effort for every step halfway to perfection.



(fig. 2)

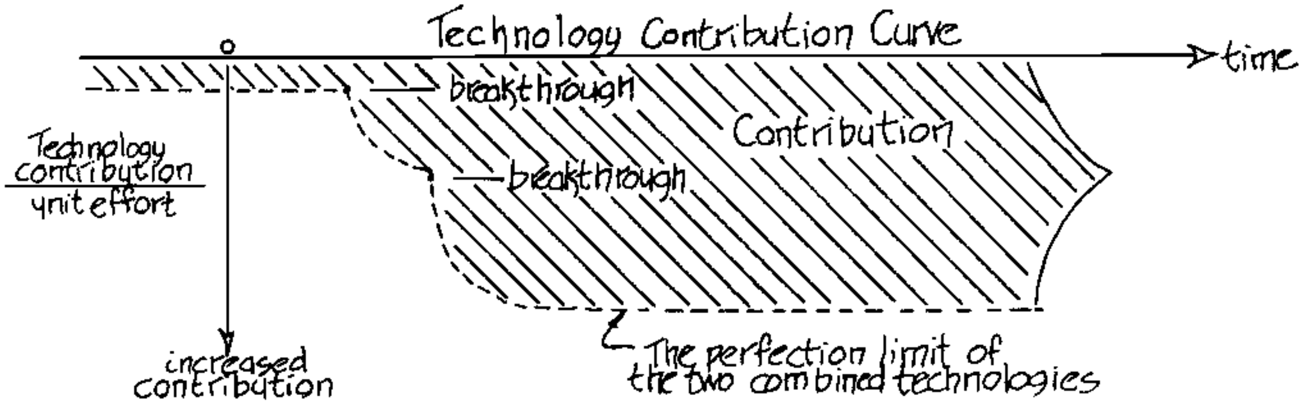
This kind of curve is the reverse of an exponential growth, and is called a exponential decay curve. It shows why very very accurate things like telescope mirrors take so much work. The refining of anything, from gears to inventions to communication processes, always follows a path of this sort. The tricky part is that the very first steps toward refinement accomplish so much with so little apparent effort. For example the discovery of the wheel made an immense difference, but each succeeding refinement, though it took no less work than making the first crude wheel, contributes successivly less of and accomplishment.

When the cart & wheel were first invented, the amount of benefit which could be acquired for the same amount of work increased radically. With successive improvements in the composite technology, the marginal benefit was less and less due to the approach of the maximum possible benefit attributable to cart & wheel technology.



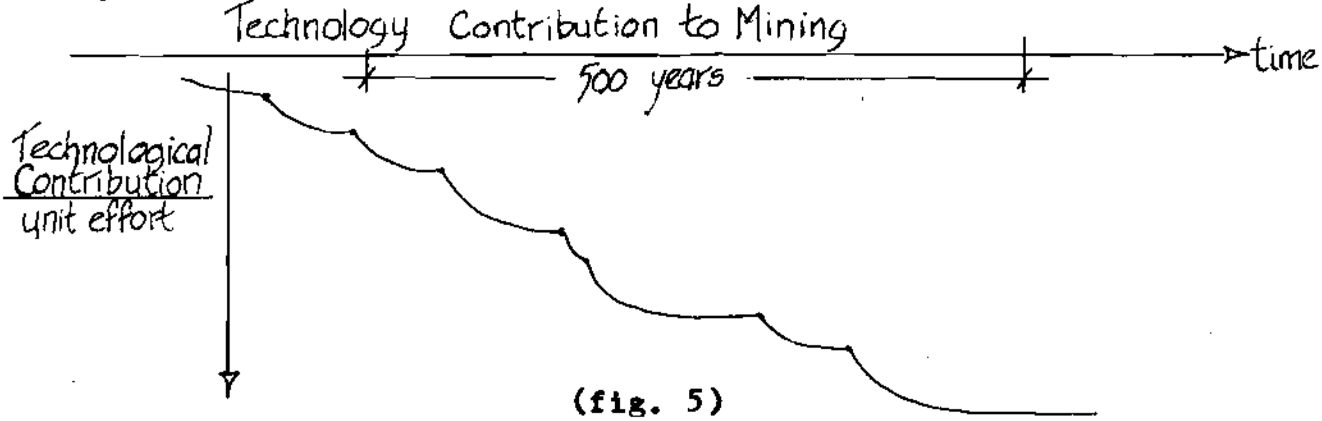
(fig. 3)

This curve is given a new name, technology contribution curve because the the area above the curve denotes the contribution of technological breakthroughs to increasing available resources. Each successive breakthrough carries with it its own perfection limit in addition to contributing to the approach to the perfection limit of the composite technology.



(fig. 4)

This same sort of technological contribution curve is followed by every sort of innovative resource development. In the complex case of, say, men and machines digging ore from the ground and transporting and manipulating the ore into products, the approach of all that a unit of effort can contribute by such techniques is likely to look more like the following. Here breakthroughs are not rapidly utilizable but improvement continues over a long period of time. A similar path would be expected for any technological development such as solar energy where the task is importantly the evolution of understanding of a system of great complexity.

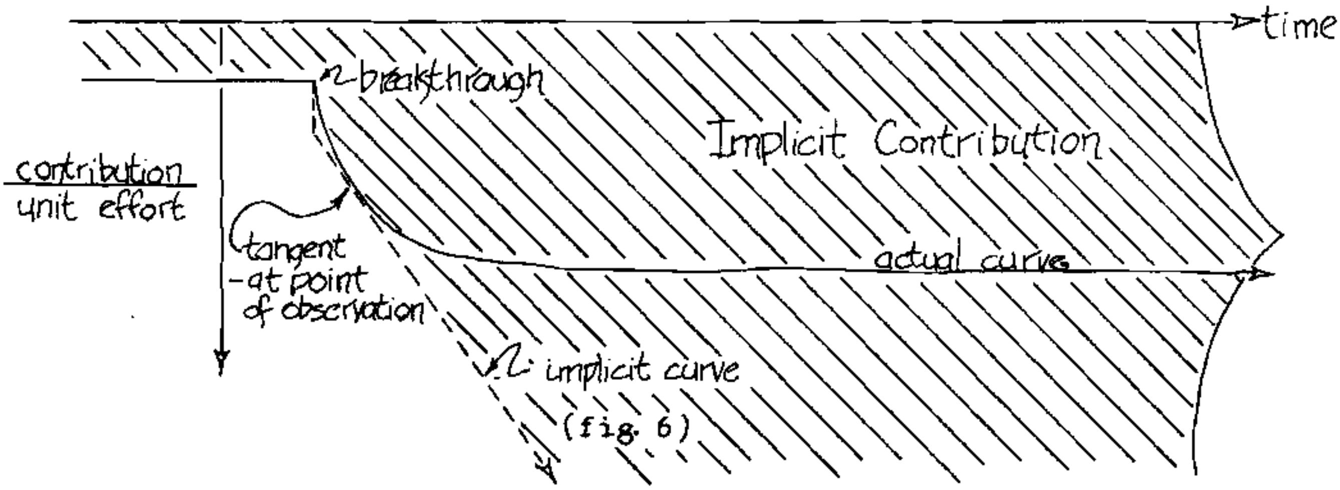


(fig. 5)

If you have accepted the foregoing, then it is already clear that exponential economic growth always fails at some point, even in a world of infinite resources, simply because technology contribution curves are never unlimited (unless you wish to make the unlikely assumption that the rate of breakthrough appearance is exponential).

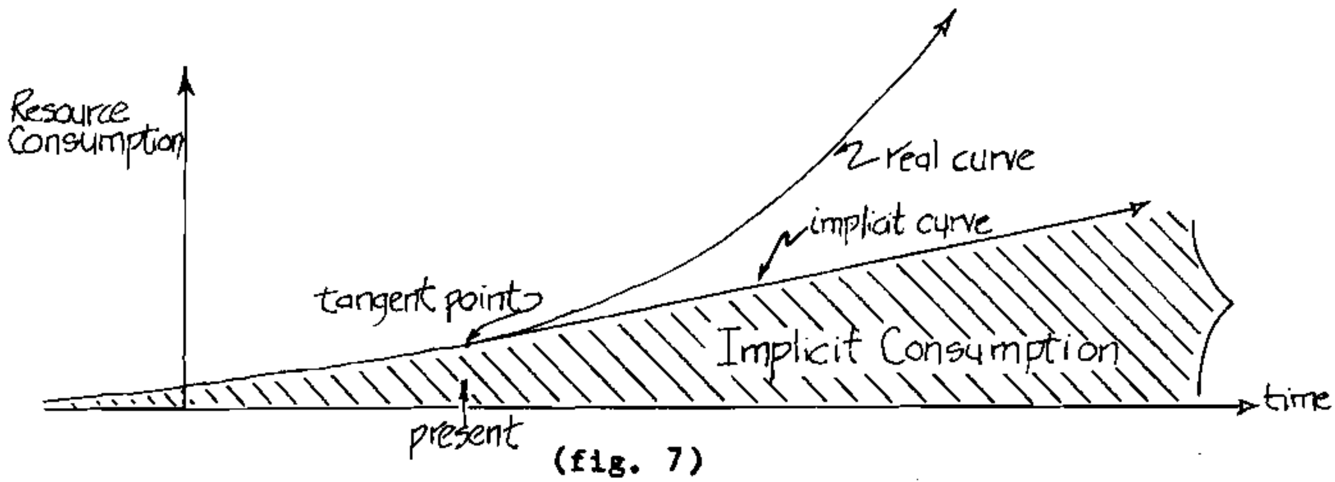
3. PERCEPTIONS OF PROGRESS

The above, however accurate, is not generally apparent. Why? I think the reason is that our only common knowledge of these complex functions is in terms of simplistic mental 'guesses'. Our knowledge of the contribution of technological breakthroughs is of the contribution at or soon after the time of the breakthrough (i.e. when people are buzzing about it). In this case, our intuitive impression of the benefits to be accrued seem to follow the initial tangents to the contribution curve and ignore the horozontal limit which will inevitably fix the amount of contribution. This impression is hopelessly infinite in its inaccuracy.



(fig. 6)

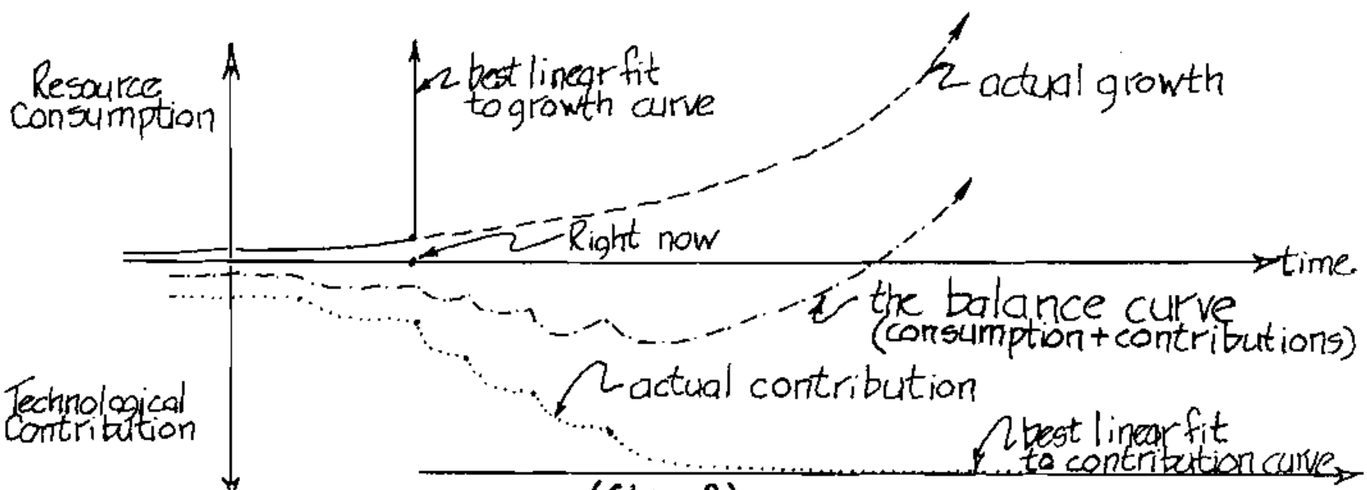
It appears that our perception of our rate of growth is also of a tangent to the true curve.



(fig. 7)

In a strict mathematical sense the hideousness of the illusion is well demonstrated by noting that the best mathematical straight line approximation of any and all combined technology contribution curves is a horizontal line and the best approximation by a straight line of an exponential growth curve is a vertical line, drawn rising straight up from whatever point represents the present time. Thus the true best linear approximation to growth allowed by innovation is infinite deficit immediately(fig. 8). This conclusion is not affected by the size of the earth. It is not affected by such unlikely things as having an infinite additional population capable of work without consumption.

The justification for this last statement is very important. The proof comes from the fact that the application of technology by an untrained population follows a contribution curve itself and is therefore finite.

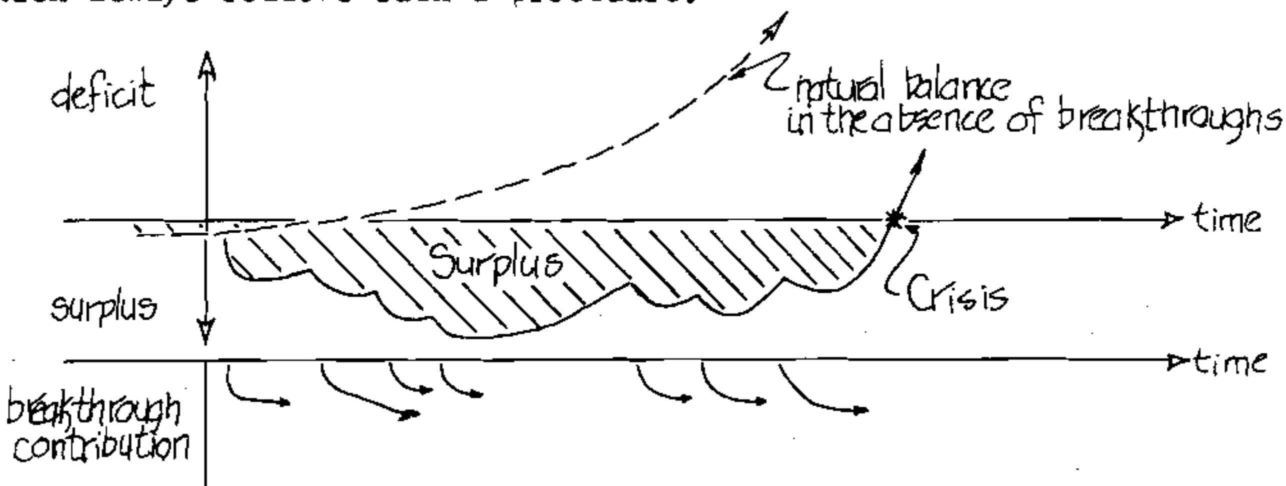


(fig. 8)

Well, so much for the reasons why offhanded impressions, however significant, fail to predict the nature of the path. The important question is why do the very 'sophisticated' economic models apparently fail as well? In the section on crisis prediction an answer is suggested.

3. CRISES

A growth crisis occurs when the supports of the growth fail to grow as fast, and the necessity of growth is challenged by confrontation with limited contributions. Figure (9) shows the balance curve which results from the exponential consumption of a series of resource contribution curves and the point of crisis which always follows such a procedure.

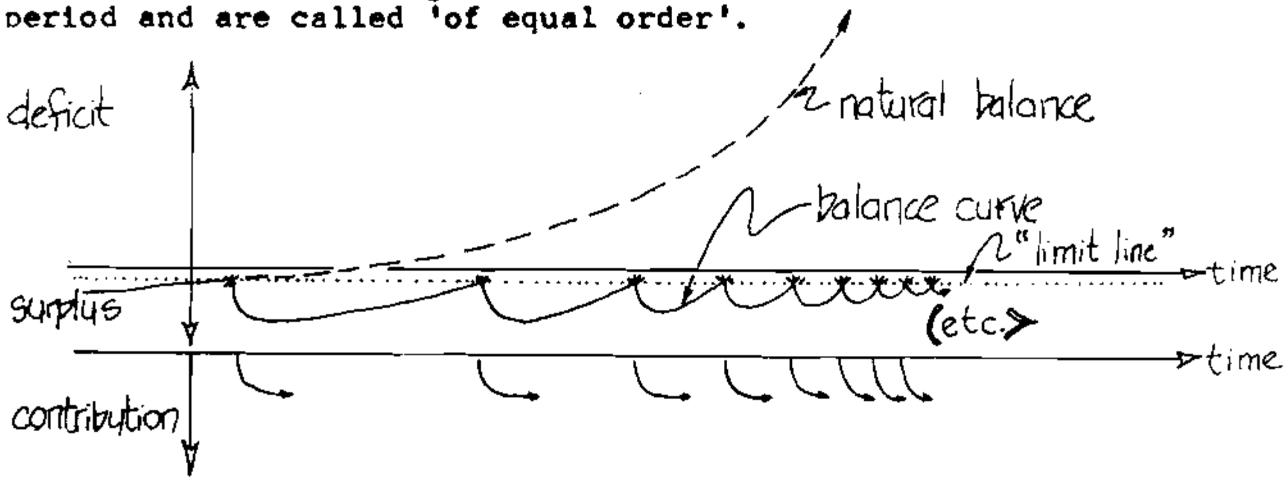


(fig. 9)

In this form it is easy to see that each contribution from a breakthrough is simply a delaying action and that as the contribution curve reaches maturity, <u>the slope of the balance curve resumes the slope of the underlying growth curve</u>. In this way the net effect of breakthroughs is to delay a crisis and make it much more abrupt when it comes.

4. THE FINAL ANALYSIS

In many situations we are able to apply new technologies as we need them. How often, as growth continues, do we need to apply new technologies? The real value of this question is as a beginning of a technique for crisis prediction. The following figure is of a single growth curve and an unlimited number of available breakthroughs of equal magnitude. The frequency of breakthrough application to keep the balance curve a marginal distance below the limit line increases exponentially. This 'crisis rate' and the growth rate both double over the same time period and are called 'of equal order'.



In our real world, there are many companion growth curves of all sorts. There are a tremendous variety of approaches to limits, response to crises, and progressions of decline. There are all sorts of breakthroughs which apply to growths, individually and collectivly. Sometimes the excess capacity of one growth can be applied to one in deficit. Sometimes the decay of a growth which failed is nutriment for some other. Sometimes breakthroughs are not applied as rapidly as is possible,thus, perhaps, limiting an unnecessary surplus. In the real world, the appearance of a crisis is not as the crossing of a line, it is more like the rapid building of a tension. In order to have the final analysis appear as lifelike as possible, the next graph (fig. 11) is drawn with three limit lines: suffering, permanent damage, and collapse. I also make the following assumptions:

1. every breakthrough is fully applied to one growth
2. any excess capacity in one growth path can be applied to any other
3. the scales of all consumptions and contributions have been equivocated
4. the paths of all the growth curves representing the culture as a whole are roughly similar in doubling time

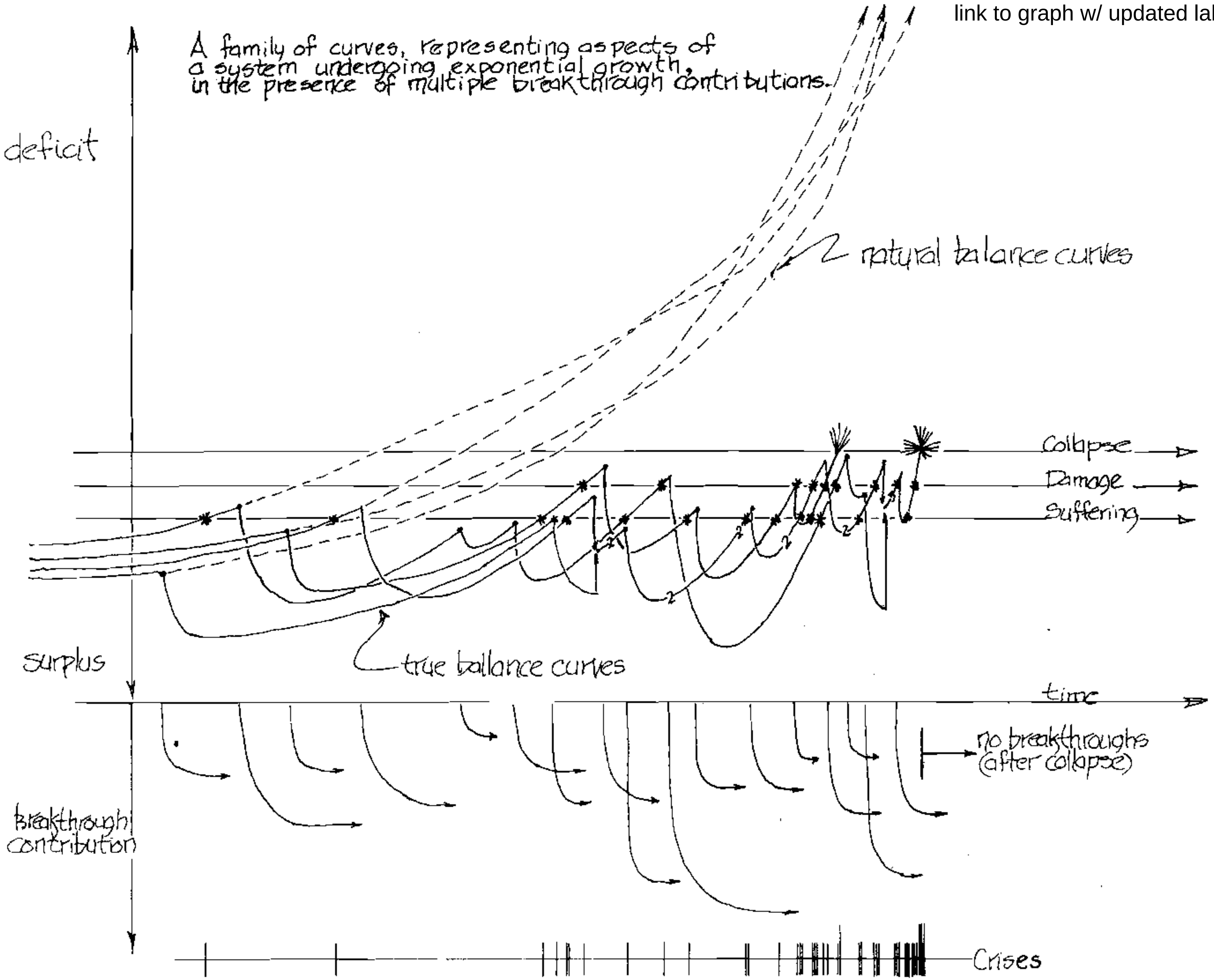
In figure (11) the crisis rate is of a much higher order than was observed in figure (10). This is due to the presence of four growth curves and the use of three, rather than one, limit line. I feel that the latter is quite reasonable, as the habit seems to be to notice each worsening step as a new crisis. Further complicating the problem is the process of neccessarily ineffectual crisis response due to more and more sloppy and hurried application of less potent breakthroughs. Under these conditions it can be seen that the doubling period of crisis appearances ranges from longer than, to approximatly ¼ of, the doubling period of the underlying growth. This means that if you thought growth could build up fast, crises can outpace growth by multiply exponential margins, i.e. leap out of nowhere.

5. CRISIS PREDICTION

The object of crisis prediction might be to get warnings or guidance, to prevent growth from going to permanent damage, or to select which growth aspect to send through collapse to composting. There seem to be three good ways to predict crisies. The first is to measure the crisis rate doubling time. Simple circumspection leads to the observation that in the last economic doubling period (18 years since 1960) we are now dealing with significantly more than twice the number of crises. We have a crime crisis, a military proliferation crisis, and a family crisis which have all re_doubled since 1960 and then a quickening governmental bankruptcy crisis, the suprise educational crisis, the expanding environmental crisis, the crisis of confidence, the terorism crisis and the investment crisis. To me these conditions imply that some one or group of our growth aspects are coming under severe stress.

(Constant growth ends in demands for complex learning that far exceed our natural learning capacity.)

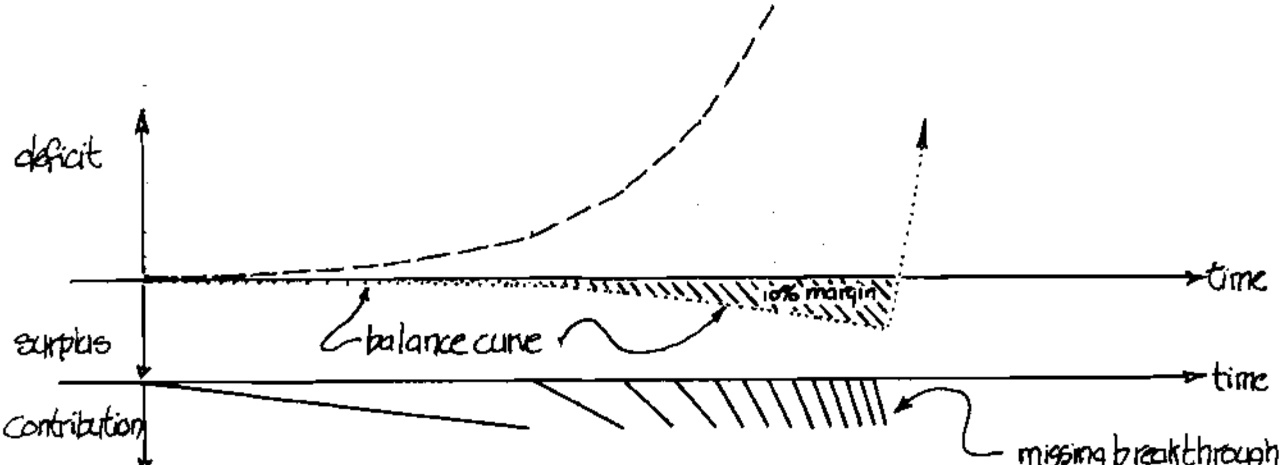
link to graph w/ updated labels



(fig. 11)

(8)

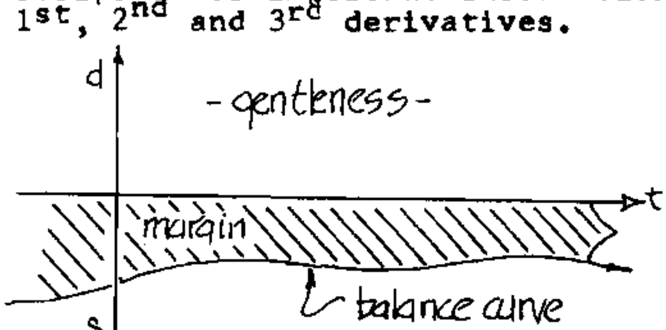
A second crisis prediction method would be to measure the time delay made by the use of breakthroughs of equal magnitude. In reality, for a social system, this might be exceedingly difficult, or it might be rather easy. Our habit is to apply breakthroughs at the rate which we need them, plus a bit for further investment. This is done by selectivly applying breakthroughs so as to maintain a margin of, say, 10% of consumption as shown in figure (12).



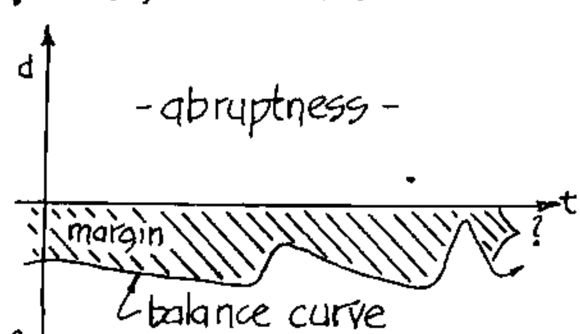
(fig. 12)

For brevity (and uncertainty) I will not attempt to fully make the connection, but it seems to me that the required rate of payoff for industrial investments should be some measure of value for technological contribution and crisis delay. In this regard, the present 'required' payoff period for industrial solar installations is two years. This seems to both be a statement of how rich industry is and how rich it has to be to stay afloat.

The third way of predicting crises which I have considered is probably the most useful. Its usefulness lies partly in its general availability and partly to its adaptability to both mathematical and intuitive approaches. This method is simply to value the abruptness of things. Mathematically speaking, abruptness directly relates to the degree of accelerations experienced in a change of direction. The abruptness of the loss of a marginal surplus for a growth system is a clear indication of the capacity to respond to stress. I think that this is the measure which modern economics fails to consider. The habit appears to be to measure the average margin rather than the abruptness of its fluctuations. This treatment of the data strips it of important information, namely the values of the 1^{st}, 2^{nd} and 3^{rd} derivatives.



(fig. 13)



(fig. 14)

6. THE SLEEPER

So far I've been speaking as if the subject were economics. It is probably not. Not only technological innovation follows contribution curves and not only material consumption follows exponential growth. In order to run our society, we also need to communicate the nature of the process and the coherence of its exponentially growing complexity. The list of profound crises, listed previously, all seem to have a unifying theme. 'What we have here is a failure to communicate.'

The train of thought,which I have followed, began with a profound sense that millions of Americans are of the opinion that we are really 'loosing it'. It appears to the author that our societal communications are in an advanced state of suffering and permanent damage similar to what one would expect near the final limits of exponential stress.

A HOPEFUL CONCLUSION

Uncontrolled exponential growth is an insidious poison. The only effect of delaying the approach of the limits of exponential growth, whether by conservation or innovation, is to make the eventual crisis more severe. Our particular brand of free enterprise insulates the pushers of the growth process by measuring societal health in terms of their continuing ability to grow exponentially. One imminent dark cloud, within which we need to find a silver lining, is the certain collapse of the value of capital; another is the certain collapse of our sense of being a people with a future.

In the face of the facts, one could despair and do nothing, hold fast by our present delusions, or ask questions to which we do not yet know the answer.

> A question - What kinds of free enterprise systems would be naturally self limiting?
>
> An Answer - Those kinds whose measures,(interest rates?) are tied to something inherently finite,(human effort?) instead of something inherently infinite,(numbers?).

I am an inventor and a serious student of natural process. I don't know how to suggest just how much of an opportunity lies silently sleeping in the above question and answer. If you look very carefully, I think you will be able to find some of the keys to a new age of awareness for man. How will it go? I don't know. Will we continue to worship exponential growth and fly headlong toward nature's compost pile, in a grand statement of supreme ignorance, or will we perhaps, be a seed to grow gently into a child of nature not yet imagined?