Prologue to the Use of Machines

This is a voyage in the manifold of work, in search for an escape from it. This manifold is now irresistibly expanding. Is it bound to absorb everything having to do with human life? Or is it going to find a limit to its expansion and become a closed, controlled universe in the larger manifold of all human activities?

This article represents also the clash between the authors' minds irreparably crippled by a modern scientific education and their direct experience of antagoinistic social movements, which seem to move beyond any logic shared by scientific theories. Here we refer especially to the 1977 movement in Italy, one of the first modern organized expressions of the "refusal of work". At that time thousands of people started thinking of how a society can be built outside the rule of work. Many responses were clearly naive. The movement was repressed. But the reasons behind it are more alive than ever. Many, like us, schizoid products of a prodigious outburst of creativity and of its failure, compelled into the narrow patterns of the society of work, still keep thinking of the 'dream'; aware that it is a dream only as far as the present reality is a nightmare.

We decided that our schizoid attitude, a source of uneasiness for us, has to be taken as a challenge: we must explore the limits of science and discover its relation to a world without work. This is a beginning.

Work: The Thermal Machine

First of all, what is work? We need a precise definition. Here is not the place to examine critically the various definitions of work used today, from the common sense one to the most sophisticated concepts. The new one we introduce has a rigorous basis and far reaching consequences, as we will see. To illustrate our point, let us go back to that important historical period in which human work started being replaced by machines on a new and seemingly unlimited basis: the passage from manufacture to industry allowed by the invention of the thermal machines. The introduction of machines into the working process brought for the first time an objective definition of what is work. After the introduction of machines work was not related anymore to the workers' physical effort, but only to the results produced by it. Physical effort has been irrelevant since them.

Indeed, the worker, as soon as the result of his/her work can be compared with the obtainable by means of a machine, is paid according to the result of his/her work, not according to the amount of physical effort implied in it.

WORK IS WORK AS FAR AS IT CAN BE COMPARED WITH THE WORK OF A MACHINE. Work is measured by the work of machines. This definition or representation of human work by means of machines is the *first abstraction of human work*. It is significant that the historical emergence of this abstraction was contemporary to the emergence of the definition of work in physics: Work=ForceXDisplacement, which is exactly the definition of a thermal machine's work.

Let us consider a few consequences of this definition of work which from now on we also will call *"the formal representation of human work by means of machines."*

1. This definition of work defines consequently the social area of work as the area of those human activities that are comparable with or representable by machines--therefore somehow these activities are the mechanized or mechanizable ones.

2. All other activities were excluded, they were not work. Housework for the most part, play, thinking, calculating, etc., were excluded from the manifold of work.

3. Thermal machines and machine-tools, on which the first abstraction of human work was based, are characterized by their cyclic activity: the same movements repeated cyclically. This established the main feature of work: repetitiveness.

4. This definition of work gave a sanction in the work process itself to the law according to which the amount of produced value is proportional to the average time socially necessary to produce it. The relevant point is that now--i.e., after the formal representation became operative--this law does not appear as a result of a complicated social interaction (the average time), but becomes embodied in the machines themselves: the produced value is proportional to the time a machine takes to produce it.

As we said before, the formal representation of working activity (by means of machines) excluded for a long time many activities which are now considered work. In particular it excluded any computing activity, data analyzing and processing and so on.

The fact that such activities are not considered work is due to a generalization of the formal representation, which has to be considered effective starting from the Great Depression or World War II.

To understand this new step in the abstraction of human work, let us observe that, once working activity is defined as that measurable by the machines' activity, it is implied that it will undergo the same generalizations as the activity of machines will. Nowadays machines are able to replace not only the part of human activity that consists of mechanically repeated movements, but also the part called computation and data processing. It is a superior activity, not reducible to mere repetitiveness. As this is the main topic of this article, we will treat it in detail.

Work: The Logical Machine

We can give a description of the logical machine as simple as it is fruitful. The idea is Turing's and it was presented in this form by Davis in 1958. The machine is made of:

1) a tape divided into squares of the same size, which can run from left to right;
2) a device which can perform four elementary operations on this tape, one for each unit time:
   a) it can write '1' on a square if it is blank, i.e., if it is =0.
   b) it can erase '1' from a square, i.e., write '0',
   c) it can shift the tape by one place to the right,
   d) it can shift the tape by one place to the left.

Each operation is controlled by an instruction. Therefore a logical (Turing) machine can be identified with the set of instructions which define it.

To make it work we only need to insert a tape with as many 1's as the input integer or integers and then read how many 1's there are when the machine stops. This is the output.

As one sees, it is not a very complicated mechanism, but we can show that this very simple machine can do whatever an electronic computer can, and vice versa. Therefore this supplies us with a good description of what numerically controlled systems and electronic computers are.

This is not all. We can build a Turing machine that generates all possible Turing machines (or atleast the set of instructions that define them), one after another. That is, for any given integer it gives us as an output a set of instructions constituting a Turing machine/ And the machines obtained in this way exhaust all possible Turing machines in a list which, unfortunately, is infinite.

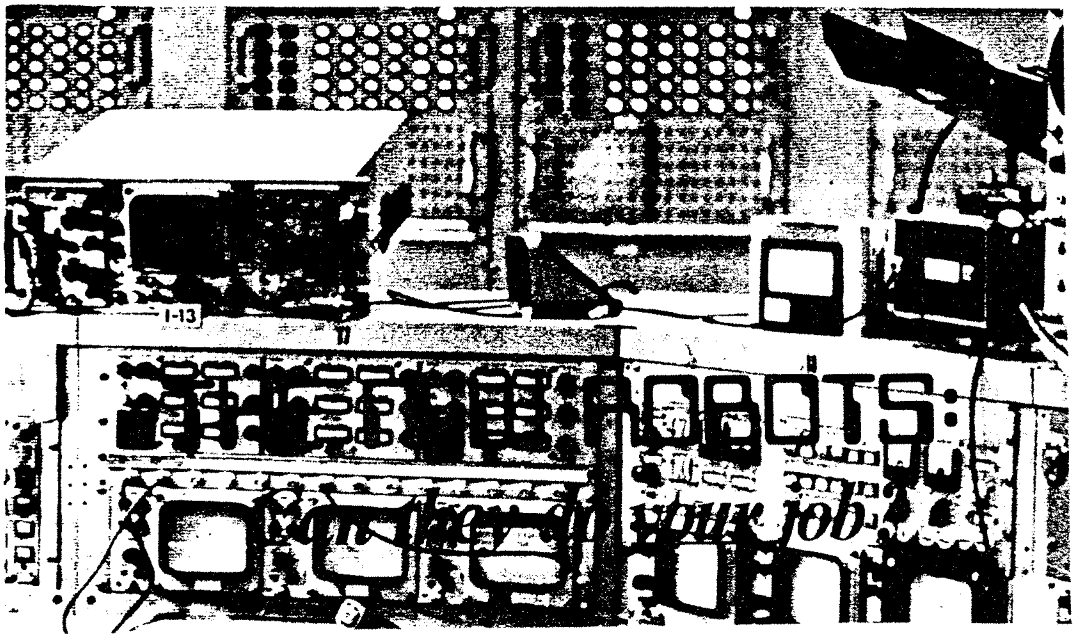
Anyhow, we have a representation of all possible Turing machines that today's science and technology can supply.

So much for mathematics.

INTERLUDE #1

With the logical machine we reach a new level in the generalization of the concept of work. Therefore we can give the following definition of computational work or, simply, work. We call 'computational work' the work that can be done either by a system which includes a thermal machine plus a machine tool, or by one or more such systems controlled by a logical machine, or by a logical machine itself.

Now remember that we are Interested in two different kinds of questions. The first is about how far machines can replace human work; in other words, about the machines' limits. The second is: why is not computational human work completely replaced by machines?



Machines' Limits

Let us call a 'function" any sequence of operations, either abstract or concrete. The relevant problem here is to decide whether a given function can be worked out by a machine or not. In other words, whether such a function is computable or not.

We can find immediately an example of a non-computable function: the problem of deciding whether any function is computable or not is not computable. In other words, there exists no machine capable of deciding whether there exists a machine which can replace any given human activity in general! (For a proof of this result see the footnotes.)

This is an example of the limits inherent to the present machines. About the limits of machines much has been written since Godel's Theorem, both in connection with logic and with effective computability.

Very roughly speaking, the common background of these discussions is that any mechanical system (including the Turing machine in its mathematical form or the logical rules of deduction of any axiomatic system) cannot control completely any language powerful enough as to "speak about itself", any language in which you can construct "strange loops". Indeed the structure of indecidability proofs goes back, even if in a very sophisticated way, to an old logical problem, the so-called semantic or 'Liar' paradox. For example, if I say, "I am lying" am I saying the truth or a falsehood? Deciding which is not easy. Indeed, if I lie then I tell the truth, and therefore I do not lie. If I tell the truth then I do not lie, and so I do lie. This looks like a word game and it appears to be unimportant for everyday life...but it is extremely important for logical machines (as well as all forms of struggles).

The point is that using a language capable of 'speaking about itself' means being able to reflect upon one's own state which is the prerequisite to modifying it. Therefore, what is called innovation, for example, seems to be so far a characteristic pertaining not to machines but exclusively to humans.

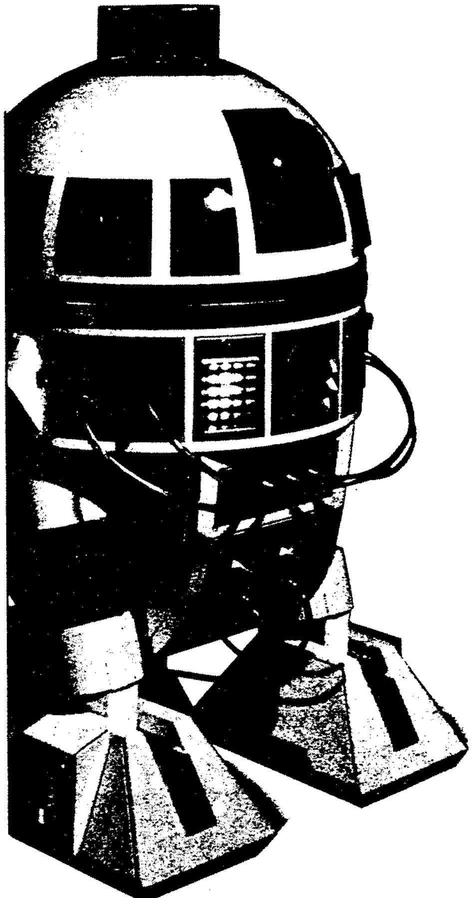
This has not to be construed as a self-celebrating assertion. It means that we are not reducible to machines qua workers, but it also means that work is not exhausted by computational work. Not only that. We had better add that in the division of work, hierarchy represents also a classification of work according to its non-computational computational content: the more one goes down in the heirarchical scale, the closer s/he gets to pure computational work, while decision, innovation and certain forms of reproduction has rather to be looked for in the upper levels of Hierarchy. The organization of work is characterized by the division between computation and non-computational content.

Economic Limits

In 'our' economic system, the rule determining the process of substitution of computational work by machines is simple and rigorous: a worker is replaced by a machine when the cost per unit product for the work is greater than for the machine. The variables coming into play as far as the cost per unit product is concerned are:

1) cost of the machine (engineering and manufacturing cost);
2) energy cost for operating the machine;
3) cost of labor.

It is easy to see that the present trend consists in increasing (1) and (2) and decreasing (3). To this, the high cost of money should be added. The present economic trend does not suggest that capital is going to utilize the substitution process unless it is forced to do so.



INTERLUDE #2

Now we have a clear framework of the relation between human work and machines. Before we proceed in our analysis, which is far more ambitious, let us consider a few consequences of what we have been saying. The connections here are far less rigorous than the exact theorems quoted before. Nonetheless, we think they are suggestive. The term "formal representation of human work by means of machines" does not mean simply the abstraction ensuing from the fact that human work is measured by comparing it to machines. It also has another important implication: society is not formalized on the basis of the overall activity of each individual, but according to the formal representation of his/her activity, or, in other words, to the computational work part of his/her activity. For the latter determines salary, working hours, social status, it formally separates classes, it cuts off dropouts. In other words, it determines the 'official' or formal society. It does not matter what one does outside his/her working place, outside his/her working time. What matters is his/her being at the right time in the work place to perform the operation required from him/her. And the more this operation is performed in a machine style, the better. This is what he/she is paid for.

From these examples we see that the formal society is, roughly speaking, the area where money circulates. No wonder. Indeed, the characteristic of all machines (not only the termal ones), viz., the rigorous Law of Value= the Value of the Product is proportional to the working time of the machine, extends now to all activities encompassed by the formal representation. Maybe it is worth reminding that this law is the basis of money. So--we say it again--the only activity one is paid for is that measurable by machine's work: what one is paid for is the result of one's working activity in the standard form determined by the work of machines, that is the result of the repetitive and/or computational activity. What is not comparable in any way with this kind of activity, is incommensurable with respect to machines' activity, is not measurable in terms of money (reproduction in part, innovation, play, etc.)

One might object at this point that, after all, also decision making officials, managers, scientists, etc., have a salary not completely unlike any other salary; that there are 'welfare' and 'unemployment' salaries; that also for some aspects of reproductive work a wage is provided. But these activities are treated according to the formal representation of work anyway, to get some evaluation however incomplete, e.g., the conditions the state applies to AFDC income to measure 'mother-work'. This pervaisive feeling of incompleteness corresponds to the common sense realization that the formal representation is an incomplete grid in order to assess the activity of a person. Being compared to some machine allows somethimes a very rough assessment, though at times it appears as a distorting mirror for reality. Nonetheless it forms the basis of the formal society.

All these seem to be quite conspicuous exceptions to the previous scheme. But they are not. We reverse the argument. The fact that jobs like decision-making, inventing, 'doing nothing', reproducing, etc., are treated according to the formal representation of work, is a striking example of its ubiquitous pervasiveness.

The point is that in our society there is no other rule than the formal representation (or Law of Value, if we prefer), and money **represents**, *warrants and enforces it simultaneously. Despite its apparent incompleteness, the formal society (that is, the social embodiment of the formal representation) pretends to exhaust the whole society, its variety, in particular wealth, through money. So, as for the above mentioned exceptions, the formal society has no choice but to treat them according to the general rule lest the entire construction crumble, but also because there is no other available criterion.*

We may wonder how this pretence can work. To understand this point, we resort to a figure of speech taken from applied mathematics: approximation. Approximation is an operative device used when a rigorous approach is either too hard or impossible. It is interesting to notice that nobody has ever deemed it worthwhile to study the nature of approximation. Approximation is almost miraculous, it reaches everywhere. With the help of computers we can approximate, or simulate, any function from the simplext estimates in scientific research to the very complex evolution of economic parameters.

Now let us take approximation, or simulation, as a category and apply it to our scheme: the formal society (the machine-based society) manages to approximate, or simulate, the real society up to the point of being confused with it. The fact that the formal representation of work can approximate the real society creates the illusion that it is complete, that it is the essence of society, that it is the just and true representation of society; and, even deeper, it creates the idea that a representation of society is possible and necessary.

Looking at the scenario just drawn, we could also argue in the opposite way with a strange result. There exists a skeleton-society formed by all existing machines, which we call the system of machines: and we could say, correctly, that it simulates the real society only as far as society agrees to stick to the formal representaiton of the working activity, or as far as society agrees to stick to machines' behavior, or in short, agrees to simulate it. Our work, inasmuch as it is repetitive or computational activity, is a simulation of machines' work. It is a simulation in the sense that it is unnecessary, it is already out of date, and thus we simulate a society where this work is necessary. The circus of history, if any, is here.

So far we have given little consideration to that crazy variable: the human being. As a matter of fact, the whole staory could be regarded as an attempt to define the human by means of machines, or to find a "rationality" in humans. But human activity is far more complex than simply mimicking machines, even when they are computers. As we have anticipated, the formal representation excludes many activities which are essential for human life such as play, love, fancy; and for the reproduction of the machines' system, such as the reproduction of the labor force.

This results in a myriad of small deviations from the norms of formal society: a social fermentation fluctuating around the point of minimal desires represented by the official society. These phenomena have hardly been studied, the most usual attitude being to call them abnormal or irrational. This is not the place to analyze the enormous complexity of these phenomena. We want to point out that maybe the most important of them concerns the attitude toward work. It is more than a simple fluctuation, it is by now a hardly ignorable concretion which has reached the status of a social law: the refusal of work.

The system of machines is incomplete both in the sense that the machinery is kept anachronistically underdeveloped and in the sense that the formal representation of society by means of today's machines is far from being a complete representation of human activity. The refusal of work pushes toward the completion of the machines' system and, necessarily, the elimination of the formal representation.

All the social noise produced by the refusal of work and similar and related fluctuations affects the orderly deployment of the formal representation. In particular, the Law of Value, which is a rigorous law when applied immediately to the working process, has to come to compromises and is apparently only an average law when applied to the entire society. The fact that it holds as a rigorous law in the working process and as an average law in general, is a direct consequence of the incompleteness of the machines' system. This in turn dictates the necessity of a ruling apparatus (state, corporations, police, ad nauseam) whose function is to enforce the validity of the law. Here we find a strong, facinating suggestion that the ruling apparatus is an image of the imcompleteness of the machines' system.

The Wealth of Nations

After this long parenthesis, let us go back to our main subject. We saw that the present economic trend is not to utilize spontaneously the process of substitution of human work by machines. In order to see the possibilities of the substitution process beyond the 'objective' compatibilities imposed by profit, we have to proceed further with our analysis of the machines' system.

We have seen that no machine exists that can govern the innovation process, and that the noncomputational human activity has the function of governing the language of innovation; that is, a language powerful enough to think of itself and which the machines cannot control.

We can say that, as far as goods production is concerned, the main activity, as the computational work is replaced by machines, is to build an information channel--the language--governing and codifying computational work. Indeed, we saw that logical machines, even though very powerful, are reducible to a few fundamental operations. The substitution process is therefore the effort to reduce work (when it is computational work, of course) to combination as complicated as one likes of those elementary operations--i.e., the four basic operations of the Turing machine.

Let us analyze this point in greater detail. To this end we resort to information theory. In such a theory, the typical scheme is the following: An example is the telegraph: the source is the message we want to transmit, the codification consists in translating it into dots and dashes and then into electronic pulses, the channel is a wire, the decodification transforms the electronic pulses into dots and dashes and finally into alphabetic letters for the reciever.

If we consider a source emitting signals chosen from a finite alphabet, $a_1, a_2, \ldots, a_k$, with the probability that each letter will be emitted, $p(a_1), p(a_2), \ldots, p(a_k)$, we can define the amount of information contained in a letter, a_i, of the alphabet by $-\log_2 p(a_i)$.

The meaning of this definition is the following: $-\log_2 p(a_i)$ is a function that increases as $p(a_i)$ decreases, so that a very frequently used letter (with a large probability) contains little information, while the occurence of letter with a small probability (and so infrequently used) implies more information. Thus in any English message the letters 'e', 'a', or 't' which occur frequently would have a small informational quantity while the letters 'z', 'q' or 'x' would have a large information content.

The measure that is used to give the average amount of information that a source emits is called its entropy and is defined as:

$$-\sum p(a_i)\log_2 p(a_i).$$

There is an important connection between entropy and the homogeneity of a system. Let us consider the simplest example. Suppose the source is someone who tosses a coin and wants to let another know the result. How much information does he need? That depends on the coin. If the coin is perfectly balanced (probability of heads=probability of tails=½), the amount of information, or entropy, is maximal, while if the coin is 'weighted' (for example, the probability of heads=.9 and the probability of heads=.1) then the source nees less information to communicate the result.

The basic idea is that the more the system is inhomogenous the more it is predictable (and so has less entropy) and therefore it needs less information to be codified or decodified into a language.

We need another important concept from information theory: channel capacity. Channel capacity is the amount of information that can be transmitted per unit time. One of the fundamental theorems in infromation tells us that, for us to be able to decodify a message, the rate of transmission (amount of information transmitted per unit time), must not be greater than the ratio of the channel capacity to the entropy of the source.

Let us consider this condition. If the entropy of the source is large and the channel capacity is small then the rate of transmission possible is going to be very small. If, on the other hand, the channel capacity is large and the entropy of the source is small the possible rate of transmission can be quite large.

Now let us notice that the substitution process is a process of codification/decodification by the non-computational work. We have seen that the substitution process means the decomposition (codification) of work into simple operations (the four operations of the Turing machine) and the recombination (codification) of these operations into complex machines. The channel that allows this transformation is a complex social mechanism. At its core is non-computational work.

It seems inevitable that the channel capacity increases as a consequence of human work being replaced by machines. Indeed, the more the substitution process goes on, the more 'complex' are the areas of human activities that are candidates for being replaced by machines. That has two consequences. The first is that the 'number of messages per unit time' to be sent through the channel increases, so that the channel capacity must increase proportionally. The second is that these more complex areas are more homogenous, or less inhomogenous. Inhomogeneity is here synonymous with structure: an activity is more inhomogeneous the more it is organized in the sense of the the machines' system, or the more it has mechanical structure. In reverse the point can be made

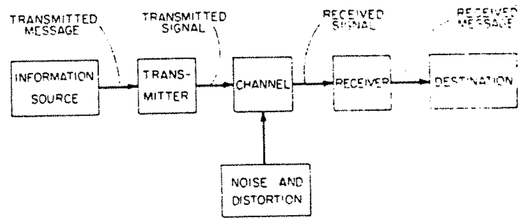


Figure 1.1 A generalized communication system.

in this way: an activity is homogeneous if it lacks a rigid mechanical structure, is fluid and complex. Putting it in terms of an equation: Complexity=Lack of Structure=Homogeneity= unpredictability. As a consequence of the increasing homogeneity of the more complex activities being mechanized the entropy of the source increases. This is a second factor that requires a higher channel capacity.

We have shown that the operation of the substitution process requires the widening of the social channel capacity. There is macroscopic evidence of this. Let us define 'primary information sector' as the part of the economy that concerns computers, telephones, media, telecommunications, and 'secondary information sector' as instruction and management. Then in the U.S., the wage bill for the workers of the information sector is larger than the corresponding bills for agriculture, industry and services together. Almost half of the GNP concerns the production and distribution of information goods and services.

If we agree that the channel capacity must be proportional to the information sector, we have rough but clear evidence that the continous introduction of machinery in the past years has been accompanied by an increasing channel capacity of the system.

Now let us try a few extrapolations based on the scheme we have just presented. Our ultimate aim is to state that channel capacity is a more abstract form of wealth than money, which is the present officially recognized and undisputed representative of wealth.

First of all we must clarify that there exists no parallelism between money and channel capacity. They pertain to two different conceptual stages. Money should rather be compared with information. Is there any equivalence between information and money?

We can reduce information to money in the sense that information can be bought and sold. But this is an impproper equivalence. Indeed, transferring money to someone else implies losing its value, but this is not true anymore for information. We can say that the circulation of money does not increase wealth, whereas the circulation of information does.

There exists the possibility for information to represent money. Most money exchanges among banks are via computers without moving real currency. Therefore an informational channel can represent a channel for the circulation of money. But it is much more difficult for a money flow to represent an information channel.

One way in which money represents information is given by the oscillations in the exchange rates of the various national currencies with respect to one another, which has become lately the so-called 'monetary chaos'. From this the economic operator can decodify information and make decisions. However, this is an information channel only in a very particular way, because only the big owners of money (in the form of fixed or financial capital) can have access to it. Money does not undergo any transubstantiation, it does not lose its very material characteristic of being owned, of representing 'property', of being a tool for controlling labor.

To maintain these characteristics of money today, the ruling apparatus is ready to diminish the circulation of money (mostly by means of high interests rates) to stifle the rates of growth of the world's economies and to impose forcibly the monetary order up to the use of war.

Why is this so? We think we have already answered this question when we remarked that the ruling apparatus is a mirror image of the incompleteness of the machines' system. Society pushes toward its completion, rendering the ruling apparatus a more and more obsolete structure. We do not mean to underestimate the complexity of the power system of our society, but it is clear that its consolidated material interests are reason enough to explain its reluctance to get out of history. Its present reaction is a typical attempt to go back in the history of social evolution. The crucial move is to narrow the channel capacity of the social system to the point that the only information channel is the circulation of money. Capital displays a good deal of clear-sightedness in this move, which corresponds to the (correct!) perception that a widening information channel is the worst enemy for the ruling apparatus.

But we have seen that the channel capacity is already enormously developed, so this move is only an expedient to perpetuate the system of power, eventually bound to be defeated. But this does not mean that it lacks effectiveness in sabotaging the social wealth. On the contrary, the damage the ruling apparatus is doing is incalculable.

From the opposite point of view, labor has a reason to exist only as long as, on the one hand, its computational work cannot be replaced by machines, and, on the other hand, there does not exist a channel powerful enough to render effective the transformation of non-computational work into wealth. For channel capacity represents wealth and the circulation of wealth in its most abstract form.

Since channel capacity is not reducible to a commodity, the process of wealth reappropriation must assume new forms. It cannot be conceived of any more as the possession of the means of production. Channel capacity can be used not owned. Owning it means stopping the circulation of information, thereby destroying wealth. The ruling apparatus is strangling the channel capacity with its present policy. Winning means freeing the channel. Widening the channel capacity is a complicated social task and we do not mean to dispose of it in a simplistic way. But it is clear with the naked eye that socializing the channel, namely increasing the number and variety of users, implies by itself increasing the channel capacity. Therefore, freeing the channel means not only getting rid of all the obstacles that obstruct the social access to it, but also inventing socializable techniques of atomized condification/decodification (direct and in real time) of the social system.

Footnotes

Work: The Thermal Machine

the themal machines: In a strict sense, by a thermal machine we mean any device transforming heat into work. The steam engine was the first industrialized way of transforming naturally stored energy into work. However here we are not interested in the process of transforming energy into work, but in the fact that a thermal machine is characterized by a cyclic activity. For historical reasons we call "thermal machine" any device with the same characteristics, for example an electric engine, a machine-tool to which a thermal or electrical machine is applied, etc. So thermal machine is a term to express a general idea in the same sense as, later on. we will call 'Turing machine' any computing device. We emphasize again that in this article the particular way of transforming energy into work is irrelevant.

the law...the average time socially necessary to produce it: There is indeed a contradiction between the "machine measure of work" and the "value measure of work".

The first measure is the ultimate 'shop floor' measure that can be used to evaluate present worker performance. It is the precisely defined ideal that can be used by all sorts of bosses to discipline workers with the inevitable threat (an extremely ambiguous one at that) of replacing the worker with a machine. What is called Taylorism is exactly this specification of the machine ideal turned into a "science". The worker is to be mechanized as much as possible (both in a thermal and logical sense) under the threat of being replaced by the machine he is to mimic: John Henry squeezed between the steam hammer and the foreman until his heart bursts.

But the machine measure of work is by no means identical to the value measure of work. One of the main differences is temporal. The machine measure can be applied to past and present work, but a value evaluation of present work is necessarily post factum (indeed, many times taking years). The value measure of work requires that the present product (the crystalization of abstract labor) go through a whole social cycle involving innumerable factors extraneous to the immediate conditions of production. Thus quite literally the capitalist "Does not know what he hath done"! Similarly the worker does not really know what quantity of his activity has been turned into work at the moment of exhuding it. This is ultimately a consequence of the social nature of capital which can have cruel consequences on both the working class as a whole (sometimes 'struggle' can produce values) and individual capitalists (after so much "effort" they go bankrupt and it was all "for nothing".)

But though capital can exist post factum, capitalists cannot. They must have a measure that is immediately applicable, "objective" and "effective". Thus the eternal attraction of the machine: a worker sans the refusal of work. But there's the rub: the lack of refusal of work is barbed with the machine's inability to produce value. Thus the ideal system of machines can only be partially realized, necessarily, for if the ideal were realized totally capital would disappear, no value nor surplus value would be produced.

Inversely, the working class is beguiled by the same ambiguity of the machine. On the one side, the machine is the measurer and counter of the drudgery of work (either potentially or actually) and in effect the intensifier and lengthener of the working day; but on the other side, it has within it the Utopia of Zerowork. Hence with and along side the Luddites we have Bill Sykes' observation: "Gentlemen of the jury, no doubt the throat of this commercial traveller has been cut. But that is not my fault, it is the fault of the knife, Must we, for such a temporary inconvience, abolish the use of the knife? Is it not as salutary in surgery, as it is knowing in anatomy? And in addition a willing help at the festive board? If you abolish the knife--you hurl us back into the depths of barbarism." The tension within working class movements toward machines (thermal and/or logical) has its roots in the very logic of the struggle against capital, in the end it cannot be resolved until capital itself is destroyed, and an evaluation of pre-capitalistic and hence pre-mechanistic knowledge can begin.

Work: The Logical Machine

Machines' Limits

there exists no machine...which can replace a given human activity: A function relates any given number with a number. For example, the square function associates 2 with 4, 3 with 9, 4 with 16, 5 with 25, 6 with 36 and so on. A Turing machine computes functions by simply applying a 'clerical proceedure' on an input number and systematically processing it until an output result is computed. It computes a function if for any given input number it computes an output number that is identical to the number the function associates with the input number. The 'clerical proceedure' a Turing machine uses is literally the program of the machine and it is built out of the four elementary operations listed.

Now we can ask the question: can any function be computed by some Turing machine? In other words, are all possible functions computable?

In order to answer this question think of the set of all Turing machines. Though there are an infinite number of them, they can be put in a fixed, linear order because the programs (i.e., the rules that fix the clerical proceedures they go through) define these machines, and these program can be put in a lexicographic order the way a librarian orders books by their titles. So we can literally list all possible Turing machines: Z_1, Z_2, Z_3,...,Z_{132},...; this list is clearly infinite and for each whole number there is a distinct Turing machine. For example, Z_{254} is the Turing machine that is in the 254th place in the list.

	1	2	3	4	5	6............r.........
Z_1	5	3	7	12	13	5............3.........
Z_2	12	21	3	0	5	6............4.........
Z_3	10	10	3	12	0	0............12........
Z_4	5	6	7	8	10	11...........3........
Z_5	5	5	5	5	5	5............5.........
⋮						
Z_r	1	2	0	4	3	7............ ....
⋮						

Now we are in a position to draw up a table where on the left side going top down is the list of all Turing machines in order while across the top of the table is simply the list of whole numbers from 1 to infinity. The entries in the table are the output numbers that the Zuring machine of that row computes when the whole number on top of the column is the input number. Thus in the table in front of us which we are using for illustration the entry on the second row second column is 21 because the second Turing machine on the master list computes as an output number 21 when the input number is 2. Now alittle care is necessary! Let us define the following function on the basis of this table, for any number n the function T will give the following result:

T(n)=n if and only if the nth Turing machine when given as its input number n does not have as its output result the number n;

otherwise let T(n)=0.

Just to get the feel for this function we see that it has only to do with the diagonal of the table (and that's why it is sometimes called a 'diagonal proof') and that its first five values are T(1)=1, T(2)=2, T(3)=0, T(4)=4, T(5)=0 and so on. This is a perfectly correct function, it associates numbers with numbers in a perfectly determinate way. But is it computable? If it is then there is a Turing machine that generates it. If that is the case, this Turing machine must be found in the list of all Turing machines, so let us call it Z_r. If Z_r exists it can be found on the left hand side of the table and the results of its computations can be found there also. But now let us consider the r-th entry on the r-th row of the table. What is it to be? By our definition of the function T, the function that Z_r is to compute, we have the following two choices: either T(r)=r or T(r)=0. If, however, T(r)=r then the entry found in the r-th place of the r-th row of the table cannot be r by definition (now is the time to look back at the definition of T!) but this leads to a contradiction! For if Z_r computes T then the r-th place of the r-th must be r. So let us consider the other alternative: T(r)=0, but if that is the case then the r-th place in the r-th row will have r in it! But that would make it impossible for Z_r to compute T!

So we can conclude that there is no Turing machine that computes T, and so we have a function that is not computable.

Now the reader might think that the above proof is just a trick. But infact this proof is exactly analogous to a famous mathematical proof of the late-19th century (the original 'diagonal proof') that demonstrated that the infinity of points on a line or in space is or an order higher (indeed infinitely higher) than the whole numbers (1,2,3,...). I.e., the continuum is a radically different thing than the discrete arithmatic of whole numbers can capture (a rigorous expression of Bergson's intuition). But the remarkable thing is the ability to approximate the infinite richness of the continuum with the relative and infinite paucity of the whole numbers. For those who will see a significance here in terms of the relation of capital to the wealth produced by living activity, we wish them well and hope the effort has been worth it!

Godel's Theorem: This theorem was proven at the beginning of the Great Depression of the 30s and it, along with Heisenberg's "Uncertainty Principle", forms one of the crucial limits of capitalist science. It can be stated quite simply: there is no formal system that can prove every truth of arithmatic. The reasons for this result are much more subtle, but roughly one could say that any system that could even begin to attempt to prove every arithmetic truth would be powerful enough to "reflect" its own mechanism of proof within itself and so would generate paradoxes like the Liar, i.e., it would create the space for a "strange loop".

Interlude #2

it creates the idea that...is possible and necessary: In a similar vein see Marx on fetishism, especially Capital, vol. I, chap. 1, sec. 4.

only and average law...entire society: The average we refer to is not the same as the sort of arithmetic average that can be inferred from the marxian statement of the law of value: an average referring to different conditions of production in different factories and industrial branches. This kind of average of course exists, but we ask the reader to abstract from it. What we want to stress here is the inevitable compromise which is a consequence of the formal representation trying to exhaust the whole society. So the average refers to the formal representation trying to cover all the non-computational activity which is being developed in our society and which is in fact not representable by machines' work. In a sense we are dealing here with a political average, even though this is too poor a word to express the complexity of what is understood.

The Wealth of Nations

The source's entropy...the average source's information: Take two sources, the first transmitting alphabetical letters in a completely random way and the second using the same symbols to transmit English senteces. In the second case the letter 'e' is more frequent than any other letter. So the information contained in a transmitted letter 'e' is less than the amount of information transmitted through another letter, say 'q'. Further, the entropy is higher for the first source than for the second. In fact one can show that the entropy is maximum when the frequency of the different symbols is the same. This explains once again the fact that high homogeneity is related to high entropy, while the existence of structure (the presence of some kind of coherence) implies low entropy.

The basic idea...decodified into a language: Any behavior that is full of surprises is highly entropic. "Intelligent" and "emotional" behavior have this in common and so they are, in this terminology, "homogeneous" because they are very unpredictable and continually escaping any attempt to formalize and structure them.

the circulation of money...information does: Circulation of money conserves ownership in the transfer process, whereas circualtion of information multiplies it. It goes without saying that in so doing it negates ownership.