PERSPECTIVES ON THE DEVELOPMENT OF ELECTRONICS TECHNOLOGY

THE IMPLICATIONS FOR DEPENDENT CAPITALIST ECONOMIES

By

*Gloria Thomas-Emeagwali**

This paper gives a brief account of the development of electronics technology. This is done primarily to situate the silicon chip in its context and to highlight certain issues related to the development of productive forces in the industrialised capitalist economy. We shall examine the transition from the vacuum tube to the period after 1947 when the transistor, integrated circuits and the micro-processor become the main components in electronic devices. Such devices and components are now central to the ongoing revolution in the means of production in the industrialised capitalist economies, reflect specific sophistication in the development of what we may refer to as silicon technology and mark a progressive incorporation of science in the production process. In the final part of the paper we shall examine the implication of this for dependent capitalist economies.

From the Vacuum Tube to the Transistor

The invention of the transistor in 1947, in the Bell Telephone Laboratories marked the end of an era during which the vacuum tube was the main component in electronic devices, an era which can be traced back to the 1880's from which time we can locate the evolution of different types of vacuum tubes (1). By the 1930's the vacuum tube would be a central component in electronic devices such as the radio, television, the telephone and other such gadgets. One of the first computers, the Electronic Numerical Integrator and Computer, otherwise known as E.N.I.A.C., invented in 1946, in the pre-transistor era, would contain 18,000 vacuum tubes, and noticeably, would weigh some 30 tons. It would be uneconomical (2).

The evolution of this particular era in the history of technology can be viewed from different perspectives. For example, it is the era which would see the emergence of I.B.M., in 1924 a specific fusion of capitals, which involved the amalgamation of *Computing Tabulating and Recording Company* and other smaller companies. It is also the era which would give rise to the radio, the television and the computer, devices which in some cases were the product of rudimentary gadgets and principles from an earlier period. By 1930 most of the important types of vacuum tubes would have been designed, whether the diode, the audion or the pentatode (3).

Edison's discovery that when positive voltage was applied to the electrode a current flowed between it and across the vacuum between

* History Department, Ahmadu Bello University, Zaria, Nigeria.

it and the filament (4), is in fact perhaps the principle of all electron tubes and it is mainly for this reason that the 1880's, during which this particular principle was discovered and articulated, might be considered important in the genesis of the electronics industry. The vacuum tube era is located within a specific period of electronic development. The rate of technological change in electronics was as yet underdeveloped as compared to later periods and science in fact played a comparatively subordinate role in invention. The rate of obsolescence of machinery was comparatively less than we would see in subsequent decades (5). Automation in the production process would be of a later era. In this period a significant proportion of factory equipment consisted of mechanical and electro-mechanical devices. If we look at some of the main equipment of that period we note that they were flagrant consumers of energy and relatively slow and costly. For example the first generation of computers coming out in this period,in the 1940's held a mere 20,000 characters in their memories, carried out only 1,800 instructions per second, and as mentioned earlier in the case of E.N.I.A.C., were uneconomical (6). Yet the electronic tube-based computer was composed of complex electronic and mechanical parts which went beyond the abilities of earlier types of computational devices.

The Development of the Silicon Transistor

It is significant that the transistor would in fact be a product not of the individual inventor working and experimenting in his basement or on the factory floor, as the case may be. Rather the transistor would be the product of what we may term a convergence of capital, sciences and scientists. It would mark perhaps the end of an era of the like of Hollerith or Benz, Daimler or Edison (7), and even if we are to cite Shockley's *Semiconductor* Laboratory of 1954 as an example of the continuing possibilities for the inventor-scientist cum capitalist, it should be noted that in 1959 the Palo Alto Plant originally set up by Shockley was bought out by I.T.T.. – a process in a specific stage of capitalism when there is a significant rise in the minimum volume of fixed capital necessary to provide the productive environment for a given commodity and when the individual scientist must sell his intellectual labour power to capital (8). It should be noted that as from this particular period most of the innovations in the electronics industry would be sponsored, directed and appropriated by large corporations like I.B.M., Intel corp., Texas Instruments, Motorola etc. (9).

The silicon transistor marked a turning point away from germanium based devices and the beginning of what one may term silicon technology,for as it would be shown,most of the subsequent developments in micro-electrons as of the time of writing have been fabricated and designed on this base material which has become the dominant material for microelectronic circuits in a complicated fabrication procedure where silicon wafers undergo diverse processes. The first transistor was essentially the point-contact transistor and consisted essentially of springy wires pressed against a germanium chunk. Raytheon, General Electric and Western Electric were some of the early producers operating then with huge contracts from the military.

From the Silicon Transistor to the Microprocessor

About four years after its initial creation in 1954 the silicon transistor became but one component in an integrated circuit of interconnections, part of a process involving chemical, photographic and other processes (11). It became but one component in the integrated circuit. By 1965 the era of large scale integration had arrived (12). It is in the context of this increasing complexity and sophistication of interconnections that we must view the micro-processor,the central processing unit of a computer,on a chip.Its capabilities and features are of central importance for this discussion since it is argued that this device has significant implications for the productive power of the industrialised capitalist economy and the production process in general. Since development of the material means of production transforms the social relations within which people produce, such transformation must necessarily be seen as significant (13). The micro-processor can be seen as a product of semi-conductor technology, computer technology and equally important Boolean algebra and logic which has specific influence on circuit design. The micro processor has been described as a device with the same logic function as a computer. It is simply «a central processing unit on a chip of silicon in the form of a large scale integrated circuit built up and fabricated from a single piece of silicon». It can interpret and execute instructions just like a traditional mainframe computer. By virtue of the ability of the semi-conductor industry to place a multiplicity of transistors in a single circuit, the micro-processor has been created. Micro-computers are now concentrated in aerospace and in terms of consumer goods they are being placed products such as office equipment,medical and laboratory instruments and traffic lights, elevators, household applicances etc. Perhaps most significant for our discussion is the installation of these devices in industry. Sherman has reminded us that all jobs with repetitive elements, or which are totally repetitive can be affected, whether batch or continuous track, commercial processes or clerical and administrative processes. Furthermore warehousing, stock control are other areas. The totally automated supermarket and electronic banking are some of the on-going examples of the effect of the technology. Sherman stresses that the productive processes based on either robotics or other micro-processor applications are cheaper, more reliable and can be worked more intensively. The fact is that we are in the era of very large scale intensified appropriation or surplus value (14).

It must be pointed out that the basic material with which these latter components are fabricated is in fact silicon. Silicon is considered to be one of the most abundant materials next to oxygen. It is an element found in sandstone. It has a melting point of 1.420'C and has a wider operating temperature than Germanium. Like most of the basic raw materials central to the micro-electronics industry, silicon is therefore easily accessible to the industrialised capitalist economies – a point that is significant for any analysis of the implications for dependent capitalism. Furthermore the silicon transistor is low in energy consumption. Oldham considers that the dominant role of silicon as the material for micro-electronics circuits is related to the characteristics of its oxide (15). The film of silicon dioxide which forms on its surface when heated is hard and durable. The *relative* ease at which the water is processed and its specific electrical properties are also important. Projections are that the chip of the future may well be heterogenous, the product of say silicon and gallium arsenide. Magnetic bubble memories are being found to be of higher memory capabilities than silicon (16). Heilmer speculates on the desirability of the use of 3-dimensional devices to supersede the present two-dimensional technology. But generally the use of silicon is predominant and the micro-electronics circuit is built up layer by layer on a wafer of silicon which is later sectioned into silicon chips (17).

As mentioned earlier, chips are now being installed into a multiplicity of devices. Ever since 1971 when Motorola brought out the first electronic digital watch, gadgets ranging from ovens to petrol pumps are being installed with chips. Specially designed microprocessors and computers are being incorporated into weapons systems, and equally significant they are being installed in the factory where they are the central units in industrial robots which mix paint, weld, and do a significant amount of labour (18). The automatic control of production processes whether in the oil refinery or in the blast furnace and the turning over of some routine tasks to automatic computerised systems are of course part and parcel of a trend whereby there is a change in the technical composition of capital, and where there is an increase in the constant constituent of capital at the expense of its variable component(19).

In 1977 the production of the mini-computer was being dominated by firms such as Data General, Texas Instruments, and General Automation. In the case of word-processing machines I.B.M. was the dominant producer, in perhaps what may well become a trend in the micro-electronics industry. By the end of the 1970's the semi-conductor industry alone had grown to a $ 6 billion market with a series of bank-ruptcies and take-overs where the battle of competition included the cheapening of commodities which could be of course sustained only in the context of economies of scale, and the increase in relative surplus value, where the larger capitals have been able to beat the smaller and we see the situation where the concentration of capital takes place in the context of 'expropriation of capitalists by capitalists'; where capital grows in one place 'to a huge mass in a single hand, because it has in another place been lost by many' (20). Similar tendencies have been manifested in other industries and in earlier periods but perhaps nowhere have these specific tendencies been so blatantly manifested than in the contemporary micro-electronics industry. The on-going anti-trust suit featuring I.B.M. (21) is but a tip of the iceberg, and an inevitable consequence of capital accumulation in the context of industrial capitalism, for, as pointed out by Engels, «competition is based on sefl-interest and self-interest in turn breeds monopoly» (22). Competition and monopoly are but two contradictory phases of the same process.

What is most significant in all of this is that a shift to the era of very large scale integration is taking place where some 100,000 devices are being fabricated on a chip of silicon 1/2 square (23). It is a tendency which can be seen as bringing about nothing less than a revolution in the potential and actual power of inanimate devices and the expansion of productive forces of the industrialised capitalist economies leading some to refer to the era as the second Industrial Revolution and perhaps less satisfactorily to Post-Industrial Society (24).

Implications for dependent Capitalist Economies
Increasing Technological Dependence

It is a sad fact that the Third World scientist is more often than not part and parcel of a comprador intelligentsia, part of the intellectual wing of the bourgeoisie serving the interest of capital. As pointed out by Hanson, the Third World scientists serve either as a pool of intellectual labour power for the industrialised capitalist economies, as local managers for multinational corporations, or in some cases are people who are there just 'to create the image of indigenous scientific capability' (25). Additionally one may add that in their own specific ways like the proverbial mimic men they are there simply to recommend processes that have already been discovered or equipment that have already been designed. The pure or applied scientist in the dependent capitalist economy is essentially emasculated. But such a tendency can only be understood in the context of the political economy of science in the dependent capitalist economy. This paper will not pursue this particular aspect of the problem except in the context of the phenomenal problems and impossibilities that exist now for the dependent capitalist economy at a stage where there is now an indissoluble alliance of science and technology in production. Science has become a direct productive force, 'being embodied in the material elements of production, the instruments and objects of labour and the techniques and organisation of production' (26).

The fundamental problem for the dependent capitalist economy where growth is not autonomous is that the future promises an era of increasing technological dependence. Such dependence is to be expected in the context of an international division of labour where technology has become a commodity in itself (27), and where laws of national security and an effective paraphernalia of patents and licenses serve to restrict the mobility of intellectual secrets (28). Rada has alerted us to the fact that there is a great deal of 'intangible' knowledge involved in micro-electronics technology and this is particularlarly so in the area of software vis-à-vis the computerized commodity and the electronic gadget, in general (29). It should be pointed out as well that the rate of obsolescence of techniques and processes are so rapid that the traditional methods of technological transfer of a world that was, comparatively speaking, more technologically static are much more anachronistic now in this phase of the electronic era (30). The history of technological change in this particular era is a history of rapid and constant change which as pointed out earlier is fundamentally motivated by the search for increased profitability. In such a period the dependent capitalist economy is severely handicapped and what we may expect is the increasing disparity between the mature capitalist units and their dependencies, vis-à-vis technological power.

Loss of the so-called Comparative Advantage

Economists ranging from Ricardo to Lewis have touted the idea of comparative advantage. Lewis has done so specifically in the context of the unlimited supplies of labour available for the capitalist-exploiter (31). Lewis in fact beckoned the capitalist to set up shop in such economies. But there is really nothing advantageous in having to sell out your labour force at murderously low wages. Be that as it may, this has been one of the tendencies in some dependent capitalist economies and in the earlier era of the so-called offshore installations this is exactly what happened (32). In the present era, where, as pointed out before, the automation of production processes has become feasible and computerised systems are even becoming generalised in terms of production, the so-called comparative advantage of the labour surplus economy is hanging in the balance. In the case of the export of primary products, some of the traditional exports may lose their importance and oil may well be one of such commodities. The recent lowering of oil prices by Nigeria has in fact taken place at a time when the on-going technological revolution in micro-electronics is in fact enhancing the rate of energy conservation and generation (33). Electronic devices are low in energy consumption. Furthermore the installation of computerised systems which can regulate energy consumption and control heating and cooling devices is a significant tendency. It can be noted however that by virtue of the fact that entirely new products and consumer items are now entering the market we can expect an increase in terms of demand for the material for such hardware. The general trend towards miniaturization in terms of the finished product should be noted, however.

Robots, Industrial Unrest and Dependent Capitalism

Silicon technology can be evaluated in terms of the fundamental changes it has brought about in the means of production and the application of labour power. We can see this in terms of the transformations underway in the nature, efficiency and productive capacity of factory equipment and the potentials for the control and organisation of labour. According to Zermeno's classification of robot applications, the loading and unloading of equipment, simple transport operation, metal working, spraying and assembly are some of the multiple possibilities in the factory system, and the utilization of these is increasing (34). For example in 1978 there were 2,500 deployed in the U.S. 2,000 in Europe and 3,000 in Japan (35). Robots enable the intensified appropriation of surplus value and profit maximization at an increased scale at the expense of a contracting wage bill and the contraction of variable capital. It has been estimated that whereas the assembly line worker earns about $ 15 per hour the robot costs $ 4.80 per hour. This calculation is based on the premise that a robot costs ₦ 40.000 (1980 estimate) and has an estimated life span of 8 years.

The unemployment rate is now 11% in the case of the U.S.A. But it is unemployment in the midst of the increased rate of concentration of capital all alluded to earlier in the paper. I.B.M. controls 70% of the market for computers (36), and in 1980 got 49% of the total revenue of $ 53 billion (37). It is estimated that the total world trade in the computer market is $ 92 billion and it is expected that I.B.M. will continue to increase its share of the market. Furthermore in terms of concentration it is estimated that corporations have spent some $ 258 billion since 1978 «to gobble each other up» ... a movement involving both horizontal and vertical mergers (38). For example Zilog, a microprocessor firm, has recently been swallowed by the oil giant Exxon.

But the proliferation of industrial unrest in the industrialised economies is an almost inevitable reality as more and more workers are thrown out of jobs and become proletarianized serving as 'a mass of human material exploitation' and with lowered bargaining power given the expansion of the reserve army in itself is bound to precipitate massive transformations internally and increased measures for the intensification of existing strategies of class domination. *The centre may not hold and things may fall apart.* But even so Third World countries may anticipate effective Vietnamization campaigns to create artificial employment and of course bring about effective market expansion.

Chips, Trade Wars and the Struggle for Markets

The on-going trade war between Japan and the U.S.A. may be seen in the context of the increased productive power of the automated factory, power brought about by the feasibility of automated continuous production, improved efficiency, increased returns from raw materials and the possibility of operations in hazardous environment by virtue of the utilization of robots (39). Such productive power must necessarily lead to over-production in the absence of market expansion (40).The fact isthat in the context of industrial capitalism ironically the saving tendency is in the group with more purchasing power by virtue of the fact that we are dealing in that context with production for surplus value and a specific process of capital accumulation, where, as Robinson explains, the lop-sided distribution of income leads to a shortage of demand (41). Morishima suggests that this in fact is a root cause of crisis in the capitalist economy. According to him such crisis is related to the 'disproportion between the consumption of the capitalists and their accumulation' (42). It is in this context that we can understand the struggle for markets and the new wave of protectionism. But it is also a warning for the dependent capitalist economy in pursuit of chip power. We have come to learn that trade wars are not necessarily fought by the cheapening of commodities or the erection of protectionist barriers alone. They may well be fought by the co-opting of the indigenous ruling class, the subversion of recalcitrant regimes and other such tactics which may be even more effective than the traditional gun-boat diplomacy. In terms of subversion it should be noted that electronic innovations in themselves have improved the *means of subversion and espionage.* Devices such as portable reception antennas which enable the reception and storage of coded signals, across-borders, serve to enhance the means of subversion and espionage and make nonsense of traditional frontiers and political boundaries (43).

The increasing rate of unemployment is in itself an important factor in the struggle on the part of the bourgeoisie for market expansion, a pressing necessity for the survival of capitalism itself. Generally we can predict an intensification of existing strategies.

The relevance for Africa is almost self evident. Comprising approximately 50 states, the majority of which fall in the orbit of dependent capitalism, the continent will be a pivotal point for such manœuvres and operations, a process to be checked only by the inevitable internal crisis and conflicts within the specific industrialised-capitalist economies, antagonistic conflicts amongst them, specific resistance from the dependent capitalist economies themselves and the deterrent capabilities of Soviet power.

Conclusion

The full implications of the on-going revolution in electronics technology are yet to be fully explored and particularly so for the dependent capitalist economy which traditionally has had its development process influenced and dictated to by external pressures and processes. It is a technology that is in fact becoming increasingly science-based. Traditionally the transfer of technology has been of limited value and by virtue of the nature of this technology greater technological dependence and a greater disparity between the industrialised market economies and dependent capitalist economies may follow. Furthermore those dependent capitalist economies which integrate the technology in their production systems may find themselves faced with specific problems in as much as the technology is in itself capital intensive. For those who refuse to do so it may be their role to become mere markets for the surplus commodities produced by the automated factory systems of industrialised capitalist economies which are bound to face the problems of over-production. In that case their role will continue to be subordinate within the international division of labour.

Footnotes

1. The term 'vacuum tube era' as used in the paper is used only in the context of the history of electronics. The writer does not wish to suggest its usage outside this context.
2. G. Bylinsky, 'Here comes the Second Computer Revolution', in Tom Forester, (ed.) *The Micro Electronics Revolution* (Blackwell), London 1980, p. 3. It should be noted that this paper focuses on the electronics industry in the *U.S.A.* in particular.
3. For example the vacuum diode of 1004, the 2-element vacuum tube of Lee de Forest in 1906, the triode of 1927. *See Electronics International*, No. 53, 1980.
4. This is also referred to as 'the Edison effect'. The first electric incandescent light will date to 1879 and in 1883 this particular principle will be articulated.
5. This is with specific respect to the turbulent years of the post 1950 period. For example 1953 improvement of the alloy process (Philco); 1954 the silicon transistor (Bell); 1957 the silicon *rectifier* (G.E.). In the 1970's we see a rapid rate of innovation and the creation of new range of consumer goods. 1971 the first electronic digital watch (Motorola); 1972 Electronic Games (Magnavow) etc.
6. Uneconomical both in terms of raw material and factory space. It occupied a room 30' x 50'. Note also that the 1983 'Lisa' marketed by Apple carries 2 million characters of memory. See *News Week January 31st 1983; Fortune Feb. 7' 83.*
7. The reference here is to Karl Benz who in 1885 would construct a single cylinder engine, Daimler who would patent his first petrol engine in the same year and Hollerith who in 1896 after uti...ng successfully his data processor machine for the U.S. census would establish the Tabulating Machine Co.
8. See Mike Cooley, «Contradictions of Science and Technology in the Productive Process», in, Rose and Rose (eds.) *The Political Economy of Science* (Macmillan), London, 1976.
   Elliot points out that there is in fact a progressive proletarianisation of intellectual workers which would increase the more computerisation enter white collar areas. *Op. cit.*, p. 78.
9. See note 5.

10. See *Electronics International*, No. 53, 1980, pp. 274–321.
11. *Ibid.*
12. The 1980's is the era of VLSI and there is a prediction that by 1999 there will be at least one million units per chip.. See article, 'The Third World's place in the integrated circuit' in *Science for people*, No. 48, Spring 1981 (pp. 23–5).
13. Marx/Engels, *Selected works*, p. 160.
14. See Sherman, 'Unemployment and technology' in Forester, *op. cit.*, pp. 367–373. For technical analysis see W. Davis, *Information Processing Systems*, (Addison-Wesley), Mass. 1978; Cooper, *Micro-processor background for management personnel*, Prentice-Hall) Englewoods Cliff – See also Gerasimov et. alia *'Fundamentals of industrial electronics'* (Mir Pub) Moscow, 1980.
15. *Op. cit.*, See Forester, p. 48.
16. C. F. Heilmer, 'The challenging face of semi-conductor technology' in *Electronic engineering*, Vol. 51, 619, 1979.
17. See Oldham, *op. cit.*, see note 15.
18. See C. Evans, *The Mighty Micro*. Collanz, 1979 – See also Forester, *Op. cit.* pp. 290–353.
19. See Capital – Vol. 1, p. 583.
20. *Ibid*, p. 586.
21. Reference is to the suit of 1975. I.B.M. started its defense in 1978.
22. Engels, «*Critique of Political Economy*», in *Economic and Philosophical Manuscripts*, of 1844, (Progress) – p. 178.
23. It has been argued that whereas the 18th century industrial revolution was essentially based on the use of fossil fuels and mechanical energy, in the present case we are dealing with a revolution based on science, technology and management and which is «sparing both in energy and materials». See Abelson and Hammond in Forester – *op. cit.*, p. 17.
24. See Daniel Bell, «The social framework of the information society» in Forester, *op. cit.*, pp. 500–549. It is highly misleading in my view of talk of «post-industrial» society in the way that Bell does. Bell characterises post-industrial society as a society where there is a change from a goods-producing to a service society. Rather the structural changes in the economy are to be seen in the context of the redeployment of labour from production into the service sector and *unemployment*, in the context of an intensified appropriation of relative surplus value and intensified goods production in the automated factory. Post-industrial society is equally a goods-producing society destined no doubt to be plagued by the contradictions spawned by over-production and a relative under-consumption in the domestic economy.
25. J. Hanson, 'Revolution and the Third World scientist' in *Science for People*, No. 48. Spring 1981.
26. Heinman, *Scientific and Technical Revolution: Economic Aspects* (Progress) 1981.

    Bell has reminded us that 19th century inventing was 'trial and error empiricism, often guided by brilliant intuitions' but that the nature of advanced technology is its intimate relations with science. See Bell *op. cit.*, p. 502.

27. See A. Smith, *The geopolitics of information* Faber, 1980, p. 111. Smith focuses on telecommunications technology in particular.
28. See for example Vaitsos, 'Patents revisted' in *Journal of Development Studies,* 1972/3.
29. See Rada, the «Micro-electronics revolution», *Development Dialogue,* 1981: 2.
30. An enlightening critique of the transfer of technology and a re-examination of the causes of technological under-development is given in the articles by Cooper and Atterea in the *Journal of Development Studies,* 1972/3. See also a recent lecture by Dr. Bala Usman which includes a most stimulating discussion on technology. See «Contractors, Consultants, and the technological bankruptcy of Nigeria today» Public Lecture, Kwara State College of Technology, Illorin, 1983.
31. See A. Lewis, Economic Development with unlimited supplies of labour, *The Manchester Journal,* 1958.
32. Reference is to the earlier stage of silicon fabrication before the era of the large scale integrated circuit when plants were set up in Third World countries such as Hong Kong and the Phillipines. The trend is now for reallocation of plants to the industrialised economies, where computerised mechanisms do the job given the development in the fabrication process.
33. See Abelson and Hammond, *op. cit.*
34. Zermeno et. alia., in «The robots are coming-slowly» in Forester – *op. cit.,* p. 184.
35. *Ibid.,* p. 190.
36. C. Evans, *The Mighty Micro,* Victor Collanz, London, 1979.
37. Rada, *op. cit.*
38. *Time Magazine Feb.* 14th 1983, pp. 46–47. See also Evans *op. cit.*
39. See for example the analysis of Bessant et. alia., «Micro-electronics in manufacturing industry», in Forester *op. cit.,* pp. 198–218.
40. Note for example the world wide slump in watches... 80 million unsold leading to a watch glut. See *Newsweek,* Jan. 31 1983.
41. J. Robinson, *An essay on Marxian economics.*
42. M. Morishima Marx's economics (CUP) 1979, p. 128.
43. See for example Mattelart, *Multinational Corporations and the control of Culture,* Harvester Press, 1979, Ch. 1.

RESUME

Cet article donne de brèves indications sur le développement de la technologie électronique. Le but ainsi visé est d'abord de placer la parcelle de silicium dans son contexte et de réfléchir sur certains problèmes liés au développement des forces productives dans les économies des pays capitalistes industrialisés. L'auteur examine la transition entre la période du «vaccum tube» et celle après 1947 qui vit le transistor, les circuits intégrés et les microprocesseurs devenir les principales composantes des outils informatiques. Ces outils et composantes sont devenus maintenant nécessaires à la révolution actuelle qui est entrain de s'opérer dans les moyens de production des économies des pays capitalistes industrialisés. Ils reflètent aussi la sophistication particulière intervenue dans le développement de ce que nous pouvons appeler la technologie du silicium et marquent une incorporation progressive de la science dans le processus de production. L'auteur conclut son analyse en étudiant ce que cela implique pour les économies capitalistes dépendantes.