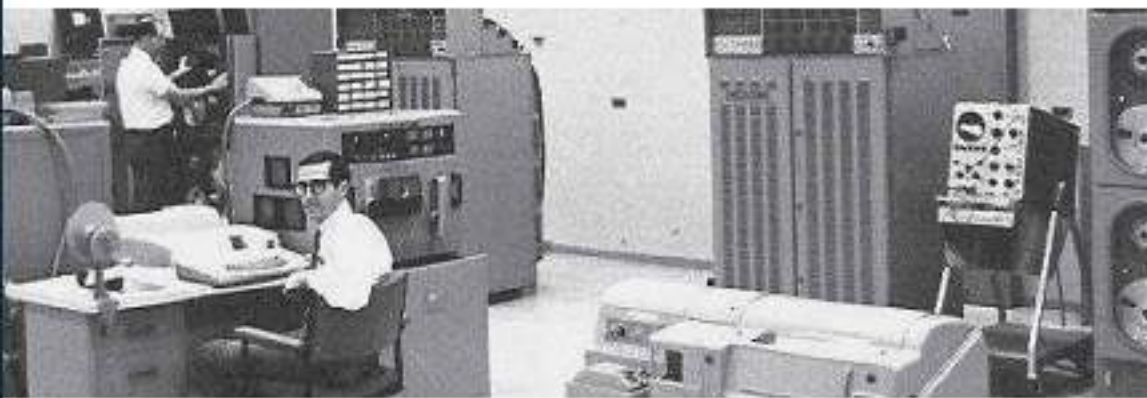
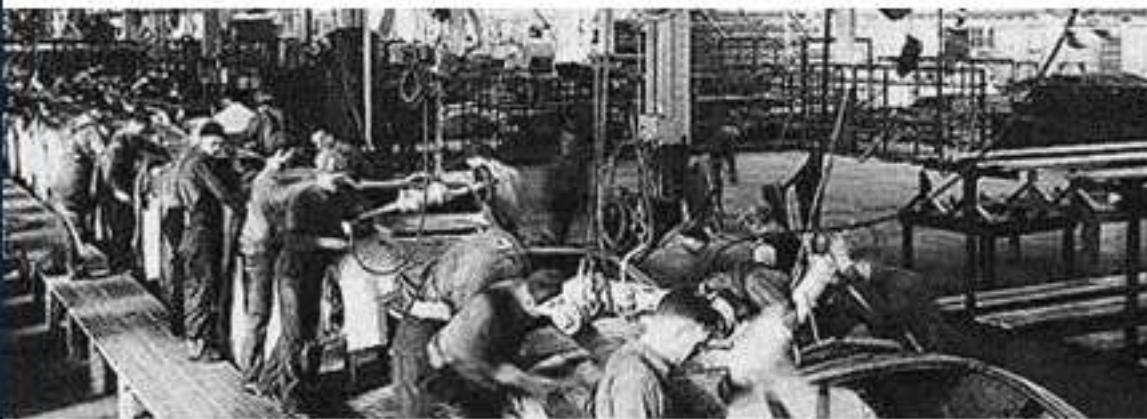


FORCES OF PRODUCTION

A SOCIAL HISTORY OF
INDUSTRIAL AUTOMATION



DAVID F. NOBLE

WITH A NEW PREFACE BY THE AUTHOR

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For M and D

Instruments of labor not only supply a standard of the degree of development which human labor has attained, but they are also indicators of the social conditions under which that labor is carried on.

Karl Marx,
Capital, I

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Preface to the Transaction Edition

All history is present history, Benedetto Croce noted, in that it is always seen through the lens of the moment of its writing. This book was conceived in the mid-seventies at a moment quite different from today. At that time the labor movement was suffused with a vitality and vision borne of rank and file insurgencies and unprecedented collaboration between trade unions and academics and intellectuals, including a generation of young scientists and engineers attuned to the interests of working people and the potential of alternative technologies. This fertile ferment produced bold and innovative responses to the intensifying challenges of computer-based industrial automation (described in the epilogue of this book). The book itself was such a response, intended as contribution to the labor movement. It aimed to illuminate the possibilities latent in the new technologies advantageous to workers and their unions by demonstrating in detail and in the concrete how technology is a political construct and, hence, subject to fundamental reconfiguration given changes in the relative power of the parties involved in its design and deployment. In theoretical terms, the study was intended to demonstrate how mute forces of production reflect in their very construction the social relations that produced them. The underlying message is that durable alternative designs and uses of technology presuppose significant alterations of the social relations. Alternative technologies do not in themselves determine changes in social relations but rather reflect such changes. At that particular moment, such changes appeared to be at hand given the energy and expansive outlook of the labor movement.

Alas, that moment did not last long. By the time this book was completed its promise had utterly vanished, in the wake of an economic recession and

corporate political consolidation that signaled the demise of the labor movement, on the one hand, and an unprecedented rush toward computer-based automation, on the other. In 1982, *Time Magazine* named “the Computer” as its man of the year. Two years later I was fired both by MIT for writing this book and by the Smithsonian Institution—to which I had been temporarily seconded as curator of automation and labor—for organizing an exhibit on industrial automation partly based upon this book. Before too long the book itself went out of print, the coupled worlds of academia and publishing now faithfully reflecting a decidedly different moment, a moment that was soberly chronicled in my subsequent book *Progress without People*.

While the belated republication of this book is certainly welcome to its author, and perhaps indicates a faint reverberation of its spirit in some quarters, it remains to be seen whether or not its reappearance coincides with any genuine revival of that spirit where it really matters.

—David F. Noble
Toronto, September 2010

Preface

This is not a book about American technology but about American society. The focus here is upon things but the real concern is with people, with the social relations which bind and divide them, with the shared dreams and delusions which inspire and blind them. For this is the substrate from which all of our technology emerges, the power and promise which give it shape and meaning. For some reason, this seemingly self-evident truth has been lost to modern Americans, who have come to believe instead that their technology shapes them rather than the other way around. Our culture objectifies technology and sets it apart and above human affairs. Here technology has come to be viewed as an autonomous process, having a life of its own which proceeds automatically, and almost naturally, along a singular path. Supposedly self-defining and independent of social power and purpose, technology appears to be an external force impinging upon society, as it were, from outside, determining events to which people must forever adjust.

In a society such as ours, which long ago abandoned social purpose to the automatic mechanism of the market, and attributed to things a supremacy over people (“things are in the saddle, and ride mankind,” wrote Emerson), technology has readily assumed its fantastic appearance as the subject of the story. And, as such, it has served at once as convenient scapegoat and universal panacea—a deterministic device of our own making with which to disarm critics, divert attention, depoliticize debate, and dismiss discussion of the fundamental antagonisms and inequities that continue to haunt America.

Confronted with the unexpected and unaccepted unravelling of their short-lived empire, Americans are now clinging to their epic myths of national identity and destiny, hoping for yet another revival. And central to these myths is a collective fantasy of technological transcendence. Whatever

the question, technology has typically been the ever-ready American answer, identified at once as the cause of the nation's problems and the surest solution to them. Technology has been feared as a threat to pastoral innocence and extolled as the core of republican virtue. It has been assailed as the harbinger of unemployment and social disintegration, and touted as the creator of jobs and the key to prosperity and social stability. It has been condemned as the cause of environmental decay, yet heralded as the only guarantor of ecological integrity. It has been denounced as the handmaiden of exploitation and tyranny, and championed as the vehicle of emancipation and greater democracy. It has been targeted as the silent cause of war, and acclaimed as the preserver of peace. And it has been reviled as the modern enslaver of mankind, and worshipped as the supreme expression of mankind's freedom and power.

The United States emerged from World War II the most powerful and prosperous nation on earth, with other industrial nations prostrate before it and the world's resources at its disposal. Today, that unrivalled hegemony is being challenged politically and economically and, as they see their dreams and dominance slip into decline, Americans are once again responding with an appeal to technology for deliverance. Initially, the revitalization of this religion—which has assumed the proportions of a major cultural offensive—has been largely rhetorical. Thus, the idea of progress has been reinvented as “innovation,” industrialization has been resurrected as “reindustrialization,” and technology itself has been born again as “high technology.” But this rhetorical escalation does little to define the dilemma or move beyond it. Instead, and perhaps by design, the new slogans merely keep Americans' fantasies alive, give expression to people's desperation, and provide further escape from serious reflection about the underlying contradictions of society. And the increasing centrality of technology in both the domestic and world economies makes it all the more difficult to question the latest shibboleths, and all the more urgent. The cultural fetishization of technology, in short, which focuses attention upon fashion and forecast, on what is forever changing—presumably with technology in command—has allowed Americans to ignore and forget what is not changing—the basic relations of domination that continue to shape society and technology alike.

I do not intend here to try to account for the ideological inheritance of technological determinism—an impoverished version of the Enlightenment notion of progress—except to note that it has long served as a central legitimating prop for capitalism, lending to domination the sanction of destiny. Fostered over the years by promoters, pundits, and professionals, the habit of thought has been reinforced as well by historians, who have been caught up by it too, have routinely ratified the claims of promoters, and have found in such determinism an easy way of explaining history. The pervasiveness of the ideology reflects not only the fixations of machine-based commodity production or the estrangement of alienated labor but everyone's desire for

a simplified life. Technological determinism offers a simple explanation for things—especially troublesome things—and holds out the prospect of automatic and inevitable solutions. Ratifying the status quo as necessary at this stage of development, technological determinism absolves people of responsibility to change it and weds them instead to the technological projections of those in command. Thus, if this ideology simplifies life, it also diminishes life, fostering compulsion and fatalism, on the one hand, and an extravagant, futuristic, faith in false promises, on the other.

The aim here is to shatter such habits of thought, which allow us to avoid thought, in order better to understand both American technology and the society that has given issue to it. The focus upon technology thus has little to do with any particular interest in technology itself or in its history, for that matter, beyond the simple recognition of the importance of technological development in human history. Rather, this inquiry into the evolution of automatically controlled machine tools is an attempt to demystify technological development and thereby to challenge and transcend the obsessions and fantasies that artificially delimit our imagination and freedom of action. Hence, the aim is not merely to put technology in perspective, but to put it aside, in order to make way for reflection and revolution.

The intimidating authority that the word “technology” has come to convey in American culture belies the ambiguity of the reality it names. Of course, technology does seem to take on a life of its own, when we remain ignorant of the actual process and blindly surrender ourselves to it, or when we act from narrowly prescribed technical ends. And the path of technological development does resemble a unilinear course, when we yield to the hegemony of those who oversee it. And, last, technology does appear to have its own impact upon our lives, when we fail to recognize the human choices, intentions, and compulsions that lie behind it. Because of its very concreteness, people tend to confront technology as an irreducible brute fact, a given, a first cause, rather than as hardened history, frozen fragments of human and social endeavor. In short, the appearance here of automaticity and necessity, though plausible and thus ideologically compelling, is false, a product, ultimately, of our own naïveté and ignorance. For the process of technological development is essentially social, and thus there is always a large measure of indeterminacy, of freedom, within it. Beyond the very real constraints of energy and matter exists a realm in which human thoughts and actions remain decisive. Therefore, technology does not necessitate. It merely consists of an evolving range of possibilities from which people choose. A social history of technology that explores beneath the appearance of necessity to illuminate these possibilities which technology embodies, reveals as well the contours of the society that realizes or denies them.

In an earlier work, *America by Design*, I attempted to challenge techno-

logical determinism by exploring the history of the institutions, ideas, and social groups which had come to choose technological possibilities in twentieth-century America. Here I am taking this exploration a necessary step further, to show how these institutions, ideas, and social groups, operating in a context of class conflict and informed by the irrational compulsions of an all-embracing ideology of progress, have actually determined the design and use of a particular technology.* Although it has belatedly become fashionable among social analysts to acknowledge that technology is socially determined, there is very little concrete historical analysis that describes precisely how. This study is meant to be a step in that direction.

In this book, then, the evolution of the design and use of automatically controlled machine tools is traced, from the point of conception in the minds of inventors to the point of production on the shop floor. Machine tools were selected because they are the guts of modern industry, and automation because it is the hallmark of twentieth-century manufacturing technology. Throughout, the emphasis is upon the social foundation of this technological development, and thus upon the ambiguity of the process: the possibilities as well as the constraints, the lost opportunities as well as the chosen path. Rather than showing how social potential was shaped by technical constraints—the typical and technologically deterministic approach—I examine how technical possibilities have been delimited by social constraints. The aim is to point up a realm of freedom within technological development, known as politics.

For when technological development is seen as politics, as it should be,

*I noted parenthetically in *America by Design* that the protagonists of that story (the rise of science-based industry) were almost exclusively men. It is necessary to repeat the observation here. For, like the technological enterprise in general, the presumably human project of automation has been overwhelmingly a male occupation and preoccupation. But so what? What does this tell us about technology or the society which creates and depends upon it? Clearly, any attempt at a social history of technology that claims to examine technological development as a social phenomenon must grapple with the implications of male domination at least as much as with other political and cultural influences. How does the historical evolution of technology reflect the inescapable fact of male domination, of both society and the technological enterprise it has generated? What are the consequences of male domination of society and the technological enterprise, both for the shape of technological development itself and, through it, for society as a whole? These are obvious and central questions. And again, as in *America by Design*, the lack of attention to them here is not the result of any oversight. Rather, it reflects a deliberate decision to address them directly elsewhere, for the following reason. The very totality of male domination renders it nearly invisible insofar as technology is concerned and thus extremely difficult to grasp and assess. Hence, the elusive significance of the obvious fact of male domination must be illuminated in a very subtle, speculative, and indirect way, quite unlike a study of the relatively apparent influences and distortions created by class relations. This calls for not only a different approach but a different plane of inquiry, one which cannot readily be integrated with the present, in a sense less fundamental, effort. To try to combine the two levels of investigation in a single study would do justice to neither. Indeed, it would invariably result in a diminution of the significance of male domination by rendering it as merely one other aspect of social determinance rather than, more appropriately, as the central focus of a different level of analysis. To avoid these pitfalls and difficulties, I have decided to pursue the examination of gender influence on technological development in a separate study, currently under way.

then the very notion of progress becomes ambiguous: what kind of progress? progress for whom? progress for what? And the awareness of this ambiguity, this indeterminacy, reduces the powerful hold that technology has had upon our consciousness and imagination, and it reduces also the hold upon our lives enjoyed by those whose social power has long been concealed and dignified by seemingly technological agendas. Such awareness awakens us not only to the full range of technical possibilities and political potential but also to a broader and older notion of progress, in which a struggle for human fulfillment and social equality replaces a simple faith in technological deliverance, and in which people, with their confidence restored, resume their proper role as subject of the story called history. For it is not the purpose of this study to demystify technology, on the one hand, only to reintroduce a new technological determinism in some alternative, seemingly more liberatory, form, on the other. This book holds out no technological promises, only human ones.

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I would like also to thank the many people whose trials and accomplishments are chronicled in these pages, for taking the trouble to jostle their memories and taking the time to share their reflections of things past. Their contributions helped me immeasurably to make sense out of a dispersed and diverse written record. As for the written record, while I was deprived of vital Air Force records due to their having been destroyed before this study began) I benefited immensely from the services of countless archivists and librarians, in particular Helen Slotkin of the MIT Archives. Finally, I would like to gratefully acknowledge my debt to the National Science Foundation for early

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D.F.N.

Part One

COMMAND AND CONTROL

We have merely used our new machines and energies to further processes which were begun under the auspices of capitalist and military enterprise. . . . Not alone have the older forms of technics served to constrain the development of the neotechnic economy, but the new inventions and devices have been frequently used to maintain, renew, and stabilize the structure of the old order. . . . Paleotechnic purposes with neotechnic means: that is the most obvious characteristic of the present order.

LEWIS MUMFORD, *Technics and Civilization*

Chapter One

The Setting: The War Abroad

For the United States, the postwar decades were an expansive time, fertile ground for technological achievement and enchantment. Infused with the pride, confidence, and triumphant optimism of victory, relatively unscarred by the actual horrors of war, and with the ruins of failed empires at their feet, Americans embarked upon their own ambiguous fling at empire. Assured for the time being of their unrivalled military, economic, and industrial might, their leaders laid claim to a boundless, prosperous, and secure future in which no goal, no vision, seemed beyond fulfillment. Yet, for all their dreams, they were haunted by nightmares of enemies without and within: of a world split in strife between two superpowers, of a humanity divided by the irrepressible antagonisms of capitalist production. “The problems of the United States can be captiously summed up in two words,” Charles E. Wilson, General Electric president, War Production Board vice chairman, and later White House advisor to President Eisenhower, declared in 1946: “Russia abroad, labor at home.” Not only optimistic dreams but paranoid nightmares defined the American outlook in the postwar decades and they colored as well the achievements of science and technology.¹

Russia, an ally of the United States, had been devastated by the war. Yet, well before the war was over, the putative threat of Soviet aggression and expansion had become, for U.S. military and foreign policy planners, the justification for a permanent, global, peacetime military establishment. Military planners especially had been pushing for a peacetime force for some time. They were haunted by memories of the precipitous postwar demobilization that followed World War I and the resulting American “weakness” which, they believed, encouraged German and Japanese aggression; they were determined not to have to repeat the desperate, traumatic experience of mobilizing

the nation for the second great war; and they were obsessed with the dire implications of modern warfare based upon air power and missiles, which dictated a capacity for rapid mobilization and undercut reliance upon strong allies and wide oceans to afford time to prepare. Thus, even before the nuclear attack on Hiroshima and Russian moves to secure a buffer zone in Eastern Europe, military leaders resolved to foster a permanent peacetime force capable of rapid defense mobilization, deterrence against aggression, and preemptive attacks, if necessary, to forestall potential threats to world peace. National security now entailed global policing. Thus, in 1943, Undersecretary of the Navy James Forrestal urged the development of a "police power and adequate strength for men of good will to curb the ruffians of the world." "We have the power now," he declared. "We must resolve to keep it."²

By the war's end, the atomic bomb and the spectre of Soviet expansion had become integral parts of this overall "ideology of national preparedness," as historian Michael S. Sherry has called it. The bomb gave rise to a strategy of massive deterrence and retaliation while Russian efforts to insulate themselves from further attack (haunted as they were by the memories of U.S. and British invasion following World War I and now by the German onslaught, which had left twenty million dead) came to be seen by War Department Intelligence as "a naked lust for world domination." Thus, U.S. leaders fashioned an active defense, one which required not only a state of constant readiness against Russian attack but an active role for America as the world's policeman. This postwar posture rested upon nuclear deterrence, air power, global bases, peacetime conscription, and a capability for periodic intervention. In addition, it required a permanent war economy based upon close ties between the military and industry, war production in peacetime, especially in the area of aircraft and missiles, and ongoing peacetime weapons research, the military-sponsored scientific substrate for the arms race.³

This postwar scenario was endorsed by Dwight Eisenhower when he became chief of staff at the end of 1945 but it did not take hold all at once or immediately. As anticipated by the planners, a war-weary nation balked at calls for a postwar military buildup, and, for a few years, military strategies gave way to political and economic strategies for attaining global security and American prosperity. Thus, in 1947, the diplomat George Kennan formulated his famous plan for "containment" of communism by political and economic means (backed up by nuclear diplomacy), and shortly thereafter the Marshall Plan was proposed, designed to rebuild Europe, create and enlarge markets for American goods and services, and contain and co-opt the communist challenge then emerging throughout Europe by strengthening center-right forces. Russia's blockade of West Berlin in 1948, its A-bomb test in August 1949, and the communist victory in China the same month, however, refuelled the postwar preparedness campaign. The National Security Council began earnestly to urge a military buildup to protect the "free world" from the "slave society" of communism, reflecting the fact that the hawkish views of

diplomats like Paul Nitze and Dean Acheson were now ascendant. Finally, the onset of the Korean War in the summer of 1950, punctuated by the entry of the Chinese into the conflict, created a state of national emergency. The invasion was cast as proof positive of the existence of a Russian-led "international communist conspiracy," the watchword of the Cold War, and the need for permanent preparedness. "Korea came along and saved us," Acheson, speaking for the hawks, later recalled.⁴

Military manpower was increased dramatically while military-related industry grew once again to wartime proportions. The decision was made to develop the H-bomb, while aircraft production grew five-fold (along with accelerated missile development), armoured vehicles by four, and military-related electronics, four and a half times. The fiscal 1951 military budget swelled to nearly four times its anticipated size. Most important, "these war-time levels took hold permanently," thus creating a permanent war economy. Between 1945 and 1970, the U.S. government expended \$1.1 trillion for military purposes, an amount which exceeded the 1967 value of all business and residential structures in the United States. Moreover, a vast "military-industrial complex," as Eisenhower named it, had sprung up, absorbing a massive proportion of industrial and technical talent; between 1945 and 1968, the Department of Defense industrial system had supplied \$44 billion of goods and services, exceeding the combined net sales of General Motors, General Electric, Du Pont, and U.S. Steel.⁵

The permanent war economy and the military-industrial complex now affixed the military imprint on a whole range of heretofore civilian industrial and scientific activities, in the name of national security. First was the emphasis placed upon performance rather than cost in order to meet the requirements of the military mission, such as combat readiness, tactical superiority, and strategic responsiveness and control. Then there was the insistence upon command, the precise specification, communication, and execution of orders, uncompromised by either intermediary error or judgment. Finally, there was the preoccupation with so-called modern methods, high technology and capital-intensive, to guarantee performance and command objectives and thereby assure the success of the mission: national security against communism. Three industries in particular became caught up in the arms race and soon reflected these military requirements: aircraft, electronics, and machine tools.⁶

The recognition of the importance of aircraft as military weapons had been the major impetus behind the expansion of that industry. In 1939, there were 63,000 workers in the aircraft and parts industries (airframes, engines and accessories). During the war employment reached an all-time peak of 1,345,000 and then dropped to 237,000 in 1946. But by 1954, owing to the buildup during the Cold War, and the postwar emphasis upon strategic air power, there were over 800,000 aircraft workers, and the industry had become the country's largest manufacturing employer. The military influence in this growth is indicated by the proportion of civilian to military aircraft produced.

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