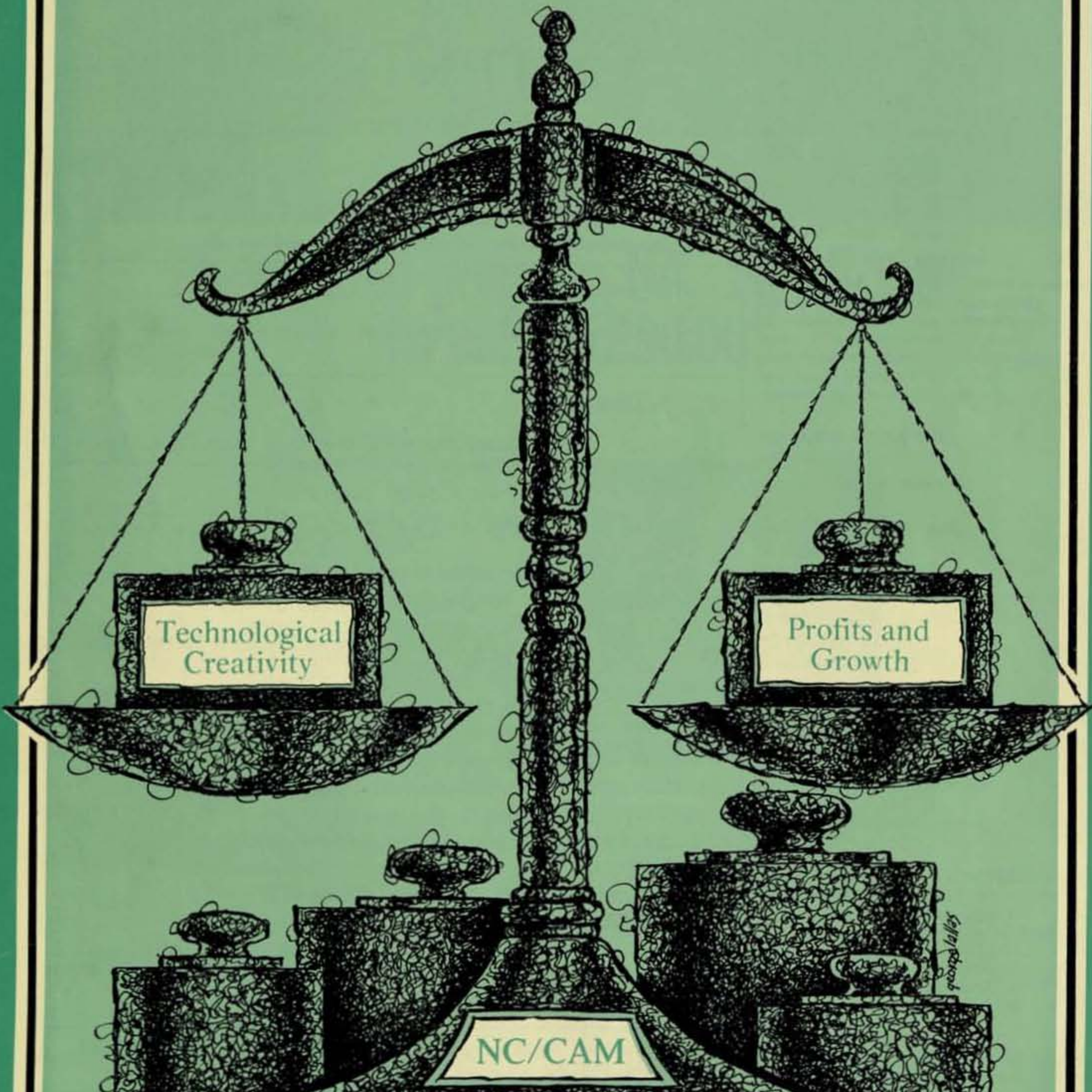
NC SCENE

July 1973

PROFITS FOR THE SEVENTIES



NC SCENE

July 1973

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DIRECTORY

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NCS Headquarters Office:
P.O. Box 138
Spring Lake, New Jersey 07762
201-449-1400

Editorial and Advertising Office:
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603-225-2631

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QUESTIONS & ANSWERS

In 1970 *the NC Scene* opened a reader exchange department: Questions and Answers (Q & A). Lack of participation suggested that practically no one had problems or questions and even fewer readers had answers or solutions. However, since the department has been inactive from lack of response, readers have missed it and urged us to open it once again. So here it is, and it will stay here as long as you want to use it and benefit from it. If you have a question or problem, write to us (*NC Scene* Q & A Department), and as space permits we will publish your letter, inviting other readers to respond. As solutions or answers arrive in response to your published problems or questions, we will then publish them.

This month we are presenting two comments to this question:

Q. *Do you think that high performance electric servos are equal in performance to hydraulic servos as machine tool axis drives? Under what conditions would each be preferred?*

A. The Pegasus Model 530 Tracing System has been successfully applied to machine tools with both electric and hydraulic Servo axis drives. In the majority of cases over-all machine performance is comparable. Where very high performance is required, we have been more successful with hydraulic servos.

Ronald R. Taylor
Sales Manager
Machine Tool Products
Koehring Pegasus Division
Troy, Michigan

A. High performance DC servos driven by SCR amplifiers are unqualifiedly superior to their hydraulic counterparts when used to drive machine tool slides.

(1) The electric solution is substantially less expensive in 80 to 90 per cent of the applications. For high torque on very large machines the price differential is less, but still runs in favor of the electric drives.

(2) The efficiency of electric drives is phenomenally greater. As an example, a "Hydrotel" type machine with a 20 H. P. spindle would require a hydraulic power supply delivering from 25 to 30 H. P to its slide drive for adequate servo response, while the actual power required to be delivered to the slide under worst load conditions might be only in the neighborhood of 0.3 H. P. The balance of the standby power is necessary *only* for acceleration. In contrast, the SCR driving the permanent magnet DC motor requires negligible standby power and might use only a total of 0.5 H. P to deliver the 0.3 H. P to the work.

(3) High torque DC servo drives are much easier to compensate for two reasons:

(a) While hydraulic servos typically have a sharp (undamped) resonance, around which it is difficult to close a high gain velocity loop; electric servos typically have a well-behaved roll off, first at 6 DB per octave, increasing to 12 DB somewhere around 300 Hz. The latter affords very high tach loop gains with no tricks.

(b) While the torque to inertia ratios (acceleration) of the combined motor and load are approximately the same for both electric and hydraulic, the load inertia is paramount in the hydraulic case while it is almost negligible in the DC motor case. This means that the servo loop transfer constants are dictated by the machine in the hydraulic application, and by the electric motor itself in the DC application. Thus, each axis of any hydraulically-driven machine is a new servo stability problem, while each axis of the DC-driven machine looks like each other axis and is very predictable and unchanging with machine wear, etc.

Roger Gettys Hill
President
Gettys Manufacturing Company
Racine, Wisconsin

NCS NEWS

NC Coordinators Task Group

Twenty-eight persons attended the second meeting of the NC Coordinators Task Group on April 15, 1973 in New York City. In a meeting summary, Chairman John C. Williams from Headquarters Army Materiel Command focused on two topics: the need for an NC coordinator and his duties.

There was unanimous agreement on the need for an NC coordinator but the subject of duties prompted a variety of opinions. Said Ed Bell of United Numerical Control: "We are all looking for a man who is a super salesman, a dedicated evangelist, has a degree in mechanical engineering, a degree in electrical engineering, a business administration major, a complete working knowledge of investment economics, an understanding of cash flow, an intimate knowledge of all aspects of manufacturing, preferably five years experience in direct manufacturing on the shop floor, and a complete working knowledge of data processing technology." He added that he would like to hire this composite man if anyone knew where to find him!

It was generally agreed that the NC coordinator may be anything from a part-time individual to a full-time organization. He may be one man in a small organization operating from a functional end whose only concern is the operation of a couple of metalcutting machines. He may be one man in a medium-sized organization, with 10 or 12 machines, whose primary concern is to gain maximum benefits from the NC machines through interdisciplinary communications. This man may operate from a managerial or advisory position at the manufacturing level. Finally, he may be a man who sits in a corporate staff position of a large diversified organization and offers expert advice and guidance to many different functional elements.

Generally, it was obvious from discussion at the meeting that the composite man does not exist. Rather, the NC coordinator would obtain the expertise in electronics, economics, or any of the disciplines necessary to support the function.

However, in all cases it was agreed that there are some basic fundamental characteristics common to all NC coordinators. The immediate need, therefore, is to delineate what these are. Walt Reed of *Machine and Tool Blue Book* is currently working on a project addressing this same topic. NC coordinator job descriptions as well as any other data for this study will be welcomed by the Task Group.

Persons interested in participating in the NC Coordinators Task Group activities should contact John C. Williams, Chairman, NC Coordinators Task Group, c/o Headquarters Army Materiel Command (AMC RD-EA), Washington, D. C. 20315.

Quality Control Committee

Bill Olson of General Dynamics was appointed chairman of the NCS Quality Control Committee on April 15, 1973 in New York City. He will head the newly-created committee for a two-year term.

In a recent report from Olson he summarized the basic objectives of the committee as the "complete interface of quality assurance with numerical control." Credit for the formation of this important group largely goes to NCS President Edward E. Miller.

The committee recognizes that quality assurance of NC processes is still in its infancy. Says Chairman Olson: "We need all the participation we can get; the stronger and greater (the) value to industry this group can be."

Goals established at the April meeting, with task chairmen, are:

Standardization of definitions dealing with numerical control and quality control: Duane Kirkpatrick, Chief, Standardization Branch, SMUA-DEES, Edgewood Arsenal, Maryland 21010.

Investigation of machine and process qualifications and acceptance techniques: Roy Blair, Allis Chalmers, Box 712, York, Pennsylvania 17405.

Impact of numerical control/quality control on government design documentation and drafting standards: Ray Miller, Senior Engineer, Federal Products Corporation, 1144 Eddy Street, Providence, Rhode Island 02901.

Evaluation of qualifications of precision accuracy by classification of design intent and/or manufacturing method and associate appropriate inspection and metrology levels: B. G. Yahne, MZ 27-2, Chief of Inspection, General Dynamics, Pomona Division, P. O. Box 2507, Pomona, California 91766.

Creation and maintenance of a numerical control/quality control documentation library: W. Olson, MZ 27-2, Fabrication Inspection Superintendent, General Dynamics, Pomona Division, P. O. Box 2507, Pomona, California 91766.

Creation of a document containing the elements of control for a quality control data base: task chairman position open to volunteers.

Questions, recommendations, assistance, and general participation in any form will be welcomed by the new committee. Send your requests or suggestions to Bill Olson, Chairman, NCS Quality Control Committee, c/o General Dynamics, Pomona Division, P. O. Box 2507, Pomona, California 91766.

NUMERICAL CONTROL SOCIETY

Numerical Control Society (NCS) is a professional organization which provides opportunities to contribute to and learn about the application and technology of numerical control in all industries. NCS is affiliated with American Institute of Industrial Engineers (AIIE); Groupement Pour l'Advancement de la Mecanique Industrielle (GAMI); International Material Management Society (IMMS); and South African Numerical Control Society (SANCS).

NC BULLETINS

Standards Produced by the TR-31 Committee on Numerical Control

With the advent and subsequent growth of numerical control, there also arose an increasing realization of the need for a standardized input medium. Based on this need the Electronic Industries Association has sponsored Committee TR-31, comprised of representatives of control systems builders, machine builders, and users.

The following standards have been prepared by Committee TR-31:

RS-244-A Character Code for Numerical Machine Control Perforated Tape. This standard is intended to serve as a guide in the coordination of equipment design, to minimize the number of sizes and codes of perforated tape used, and to minimize the variety of perforated tape preparation equipment required by users of numerically-controlled machines.

RS-267-A Axis and Motion Nomenclature for Numerically-Controlled Machines. This standard is intended to simplify programming, to simplify the training of programmers, and to facilitate the interchangeability of control tapes.

RS-273-A Interchangeable Perforated Tape Variable Block Format for Positioning and Straight Cut Numerically-Controlled Machines.

RS-274-B Interchangeable Perforated Tape Variable Block Format for Contouring and Contouring/Positioning Numerically-Controlled Machines.

RS-326-A Interchangeable Perforated Tape Fixed Block Format for Positioning and Straight Cut Numerically-Controlled Machines.

RS-273-A, RS-274-B, and RS-326-A are intended to serve as guides in the coordination of system design, to minimize the variety of program manuscripts required and the number of word and block format systems used, to promote uniformity of programming techniques, and to foster interchangeability of input tapes between numerically-controlled machines of the same classification by type, process function, size, and accuracy.

RS-281-A Electrical and Construction Standards for Numerical Machine Control. The purpose of this standard is to provide detailed specifications for the application of electronic, static, and associated electrical control equipment, to numerically-controlled machines so as to promote safety to personnel, uninterrupted production, and long life and low maintenance cost of equipment.

RS-358 Subset of USA Standard Code for Information Interchange for Numerical Machine Control Perforated Tape. USA Standard Code for Information Interchange (USAS X3.4-1967) is designed to achieve coding uniformity for information interchange between data processing and communication systems. This standard describes a subset of USAS X3.4-1967 for numerically-controlled machines and associated perforated tape preparation equipment.

The above abstracts are published with the permission of the Electronic Industries Association.

Economic Guidelines for Justifying Capital Purchases

A new approach to the economic justification of technologically-advanced equipment is the subject of a report just released by The University of Michigan's Industrial Development Division. Donald Smith, one of the authors, stated that the guide was prepared after it became clear that one of the biggest barriers to increased U. S. productivity was that economic justification techniques have notably lagged behind automation improvements.

As a result, more productive automated equipment, and particularly numerical control purchases, are too often vetoed by accountants for lack of complete and sound justification. "Too often," Smith said, "the production manager's equipment proposal lists direct labor savings as the chief economic payoff. This is a shocking practice in light of the findings of our survey of 356 users of numerical control, which showed that indirect savings usually outweigh the direct labor economies, often by severalfold."

Some other savings factors that should be considered, according to the numerical control survey, are the following (ranges of savings reported are shown): machine set up–20–70%; material handling–20–50%; inspection–30–45%; scrap and rework–30–45%; work-in-process–20–30%; and part cycle-time–20–75%. Smith pointed out that the survey results published in the report identify all substantive savings factors as well as the amount of savings experienced by the 356 firms.

The techniques developed in the manual, according to Professor Wilbert Steffy, a co-author, can be used for the justification of the purchase of a broad range of capital equipment investments. The authors conclude that these concepts and principles will significantly reduce the chances of a proposed automation investment being erroneously rejected in a financial review that failed to include the whole savings story.

The 141-page report, *Economic Guidelines for Justifying Capital Purchases,* is available from The University of Michigan's Industrial Development Division in Ann Arbor, Michigan for $5.00.

NC SHIPMENTS FOURTH QUARTER 1972

from Series: MQ35W(72)-4, April 1973, Current Industrial Reports, Metalworking Machinery, U.S. Dept. of Commerce.

During the fourth quarter of 1972, the value of factory shipments of numerically controlled metalworking machine tools totaled $52.4 million up 37 percent from $38.2 million shipped during the third quarter 1972. Numerically controlled machine tools accounted for 15 percent of the total value of industrial type metalworking machine tool shipments during the fourth quarter 1972 and 14 percent of the value of products shipped in the third quarter 1972.

A large percentage of the value of all numerically controlled machine tool shipments during the fourth quarter 1972 were for cutting-type machine tools, predominantly represented by lathes, 38 percent; machining centers, 28 percent; boring machines, 13 percent; milling machines, 11 percent. The corresponding percentages for the preceding quarter were: Lathes, 46 percent; machining centers, 26 percent; milling machines, 8 percent; and boring machines, 7 percent.

TABLE 2.--TOTAL SHIPMENTS AND UNFILLED ORDERS OF NUMERICALLY CONTROLLED AND AUTOMATIC MECHANICAL METALWORKING MACHINERY BY TYPE OF CONTROL AND TYPE OF MACHINE

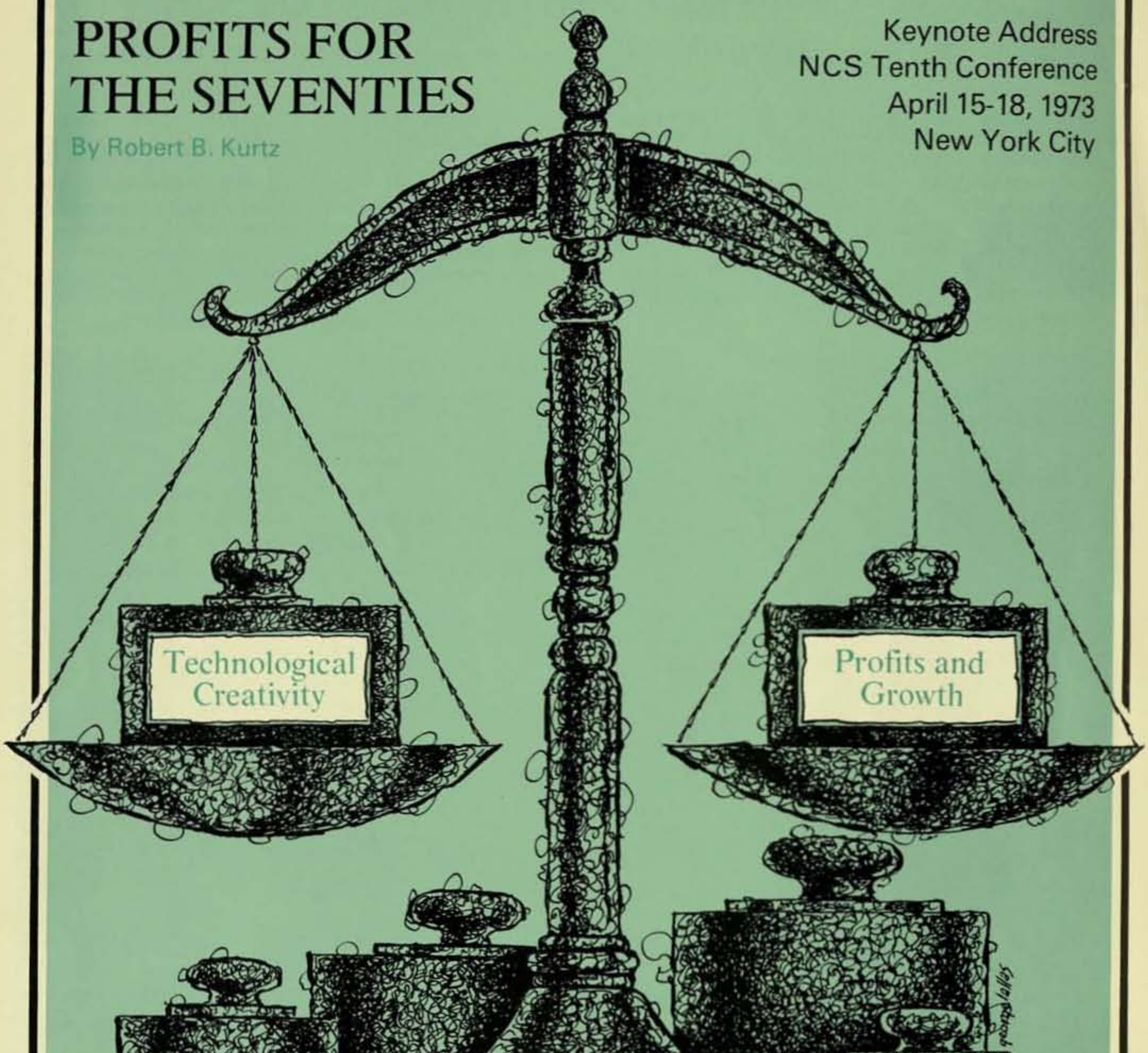
SIC CODE	ITEM	QUANTITY SHIPPED - NUMBER MACHINES	PRODUCT SHIPMENTS MACHINES AND CONTROLS THOUSAND DOLLARS	PRODUCT SHIPMENTS CONTROLS ONLY THOUSAND DOLLARS	UNFILLED ORDERS END OF QUARTER NUMBER MACHINES	VALUE OF UNFILLED ORDERS MACHINES CONTROLS THOUSAND DOLLARS	VALUE OF UNFILLED ORDERS CONTROLS ONLY THOUSAND DOLLARS
		FOURTH QUARTER 1972					
	METALWORKING MACHINERY, TOTAL	535	52,449	13,365	1,334	182,054	50,565
	BY TYPE OF NUMERICAL CONTROL:						
	POINT-TO-POINT POSITIONING	203	17,347	3,598	337	50,763	15,697
	CONTINUOUS PATH ACTIVATED BY TAPE OR PUNCH CARD	323	34,323	9,576	977	128,310	34,438
	DIAL OR PLUGBOARD TYPE OF PRERECORDED MOTION PROGRAM CONTROL	9	779	191	20	2,981	430
	BY TYPE OF MACHINES:						
3541100	BORING MACHINES	25	6,668	1,359	126	30,020	12,222
3541200	DRILLING MACHINES	21	1,506	333	25	4,332	681
3541500	LATHES	182	20,021	5,865	578	66,287	20,941
3541600	MILLING MACHINES	102	5,688	1,269	83	11,047	1,743
35418PT	MACHINING CENTERS	158	14,540	3,716	434	61,836	13,275
354****	ALL OTHER METAL CUTTING AND METAL FORMING	47	4,026	823	88	8,532	1,703
		THIRD QUARTER 1972					
	METALWORKING MACHINERY, TOTAL	385	38,237	9,675	1,090	151,876	36,866
	BY TYPE OF NUMERICAL CONTROL:						
	POINT-TO-POINT POSITIONING	144	9,763	2,152	277	41,670	8,898
	CONTINUOUS PATH ACTIVATED BY TAPE OR PUNCH CARD	231	27,137	7,319	800	108,485	27,656
	DIAL OR PLUGBOARD TYPE OF PRERECORDED MOTION PROGRAM CONTROL	10	1,337	204	13	1,721	312
	BY TYPE OF MACHINES:						
3541100	BORING MACHINES	15	2,326	682	100	26,388	6,314
3541200	DRILLING MACHINES	24	2,105	342	23	4,092	600
3541500	LATHES	144	17,726	4,921	480	55,339	16,418
3541600	MILLING MACHINES	62	3,127	680	61	11,661	1,835
35418PT	MACHINING CENTERS	101	10,006	2,518	355	46,668	10,128
354****	ALL OTHER METAL CUTTING AND METAL FORMING	39	2,747	532	71	7,728	1,571
		FOURTH QUARTER 1971					
	METALWORKING MACHINERY, TOTAL	341	39,939	9,067	581	107,700	23,288
	BY TYPE OF NUMERICAL CONTROL:						
	POINT-TO-POINT POSITIONING	104	10,593	2,076	146	30,290	6,222
	CONTINUOUS PATH ACTIVATED BY TAPE OR PUNCH CARD	226	28,473	6,815	425	76,598	16,890
	DIAL OR PLUGBOARD TYPE OF PRERECORDED MOTION PROGRAM CONTROL	11	873	176	10	812	176
	BY TYPE OF MACHINES:						
3541100	BORING MACHINES	24	4,899	1,142	74	23,729	4,981
3541200	DRILLING MACHINES	37	2,782	513	37	3,184	588
3541500	LATHES	111	11,266	3,298	245	37,530	9,916
3541600	MILLING MACHINES	32	4,450	932	27	8,787	1,221
35418PT	MACHINING CENTERS	104	13,323	2,751	171	30,684	6,096
354****	ALL OTHER METAL CUTTING AND METAL FORMING	33	3,219	431	27	3,786	486

* REPRESENTS A COMBINATION OF CODES.

PROFITS FOR THE SEVENTIES

By Robert B. Kurtz

Keynote Address
NCS Tenth Conference
April 15-18, 1973
New York City



Your conference theme, "NC/CAM–Profits for the 70s," is particularly well-chosen. The restoration of profitable growth is the industry's number one priority in the 70s, and if your theme, and this conference, contribute to the accomplishment of this profit-oriented objective, your 10th anniversary will have been a key milestone, indeed, in the industry's progress toward the promising era of computer-aided manufacturing.

CAM, or more accurately, the complete control of manufacturing through automation, is a goal that all of us believe in, and one we all believe to be possible. A more complete establishment of NC in manufacturing must come first, however, and there are short range actions we all can take, *now*, to help our businesses produce profits through NC.

I am optimistic that we will take these steps and that we will accomplish this profit objective. My optimism stems from the fact that, in this industry's short history, unified action by suppliers and users has always produced results. To a very real extent, in fact, the industry's history is a product of such unified action. It's a product of the ability on the part of all the industry's various operating elements–its control suppliers; its machine tool builders; its support partners who supply computers, peripherals, and software; and its customers—those who purchase and use NC—to work cooperatively with one another and to convert these cooperative efforts into optimum benefits for all. If this cooperative spirit can be harnessed in the direction of improved profits, CAM and the fully automated factory are sure to follow.

Just how far this spirit has brought the industry to date can be seen from a brief look at the technological advancements in the industry's hardware and software in the brief span of only 18 years. This is a history that encompasses some of the most creative technological work done in manufacturing, and for this reason, it's a history worth repeating.

Before 1955, of course, there was no NC. There were experiments with tracer control and record-playback, and there was the work done at M.I.T. for the U.S. Air Force's Air Materiel Command. It was not until 1955, however, that all of this work culminated in the introduction of the first commercial NC unit—a Sundstrand lathe using control made by General Electric.

By 1957 NC had become a more practical commercial proposition; and in that year, simple, standardized, two- and three-axis positioning control was introduced.

A year later another new concept called the machining center was unveiled, and this was a machine tool designed from the ground up by Kearney and Trecker, specifically for numerical control operation. At this point NC was on its way to becoming a way of life in the machine tool industry.

Two years later, and only five years after the first commercial unit, NC entered a second technological generation when solid state control was introduced.

By 1964 additional advancements had been realized, and the industry had its first low-cost, limited-option contouring control.

In 1967 Technology Generation No. 3 began and controls using integrated circuit technology made their appearance.

It is time to strike a new balance between technological creativity and profits.

A year later user interest began to develop in another new concept—that of using a computer to distribute path data to several NC machines operating as a group. By 1970 this concept, too, had become a reality, and direct numerical control was a feature of the 1970 NMTBA Machine Tool Show.

This Show also marked the advent of the first *computer* numerical controls, and these controls have been applied to a number of different machine tools since.

And while the industry's hardware was advancing, its software and support capabilities have not been far behind.

In software, again, the Air Force led the way, and it was work done through the Aerospace Industries Association, involving M.I.T. and 21 pioneering industry partners, that produced APT, the forerunner of all NC programs.

By 1960 APT had reached production system status, and work done with this program, and with ADAPT, enabled the industry, in the early 60s, to control what was becoming a troublesome proliferation of tongues. The thrust at this time became one of concentrating on language capability as opposed to language compatibility, and one of making whatever language or program was used a servant rather than a master. Major contributions during the period, from suppliers and users alike, included: sculptured surfaces, family of parts programming, and the industry's first generalized post processors.

Programming itself spawned yet another category of industry partners over the period, and these were the various software and support houses, both computer-owned and independent, which responded to the industry's needs in the area of computer-assisted programming.

In this field, M.I.T. was in on the ground floor again, working with the Department of Defense, and so was Dartmouth. In 1964 G.E. and Dartmouth established the feasibility of remote data processing by effecting the first practical communication link between a local teletype and a remote computer. While this data link was first used in the processing of engineering data, it was less than a year before the useful innovation had spread to NC programming and NC tape preparation.

Time sharing was a viable commercial proposition by 1965, and since that time the number of companies capable of providing economical programming, and programming support services, has increased at a rapid rate.

What all this history confirms, I believe, is that when a healthy spirit of partnership and cooperation is operating in the numerical control industry, there is literally nothing that cannot be accomplished.

The NC products and services that this industry has created have freed man from the limits previously imposed on him by his ability to turn a lead screw. They have made possible design parameters previously considered beyond his reach. They have multiplied his productive capability; and beyond this, they have given to us all an unprecedented opportunity to exercise control over the entire manufacturing process.

Despite all this, however, there is much that remains to be done, and a hard look at the realities of the current industry situation bears this out.

First of all, despite the proven worth of NC, domestic shipments of numerically-controlled machine tools have declined at a rate of 17 per cent per year over the past five years, and this compares with a positive growth rate of 34 per cent per year, which existed in the prior eight years.

While some attempt has been made to explain this dramatic deterioration in performance by pointing to economic factors beyond our control, specifically, the recession in the machine tool industry at large, it's difficult to accept this as the entire root of the problem.

It is a fact, after all, that only one per

continued next page

Commitment to NC is not enough – it is the commitment to make NC pay that counts.

PROFITS continued

cent of all the metalcutting machine tools in America are presently numerically-controlled–21,000 machines out of a possible two million, and this low level of market saturation suggests that the NC industry should have been able to generate orders, even in the face of lower levels of available business, by simply increasing its share of the number of tools shipped. This is how the industry grew in every year from 1959 through 1967.

There was also the opportunity to turn to the nonmetalcutting applications of NC, and this is an opportunity to which the industry can turn for business at all times. The feasibility of such applications as spot welding, coil winding, glass cutting, wire wrapping, and circuit testing has been well-established, and yet these markets have been even less well-penetrated.

The history of our recent recession shows also that NC shipments in metalcutting actually declined before the market dropped, and despite a modest rebound during 1971 and 1972, the industry does not today enjoy the penetration of metalcutting shipments that it did in 1967.

Simultaneous with this decline in market penetration, there has been a deterioration in the profit levels of some of the industry's key machine tool builders, and a deterioration as well in the profits of some of its key hardware and software suppliers. This is another economic warning cloud of signifieance.

Finally, the industry's most attractive new hardware offerings, DNC and CNC, have not grown as predicted. Users have found it difficult to justify the price tags involved, and this is due in some part to the fact that benefits projected for previously initiated NC projects have not materialized. It is also due to the fact that users collectively are digging in their heels about adopting these new concepts before they first prove to themselves that the benefits of concepts already purchased can be realized. As a manufacturing engineering acquaintance of mine put it: "How can I afford to embark on a new level of sophisticated machinery when I know that a high percentage of the NC machines I have on the floor now are not being used as effectively as they should be?"

What then do minimal market penetration, declining profits, and a slowing in the rate of acceptance of new products add up to? What are the implications for suppliers? What are the implications for users? What is the "something more" that's needed?

Taking these questions one at a time, I believe that the basic need conveyed by the current situation in the industry is this–that it is time to strike a new balance between the technological creativity of which the industry has been so proud in the past and the profits and growth which are so badly needed for the future.

For suppliers this means a renewed dedication to the economic imperative that profits now are the key to success in the future. I do not mean to imply that suppliers in the industry will, or should, relax their efforts aimed at technical progress. This work must continue. What I am suggesting, however, is that the focus of suppliers' work should be increasingly directed toward what is needed, rather than what is possible, and toward the development of new, cost-effective approaches to solving manufacturing problems, This is the industry's justification for being.

The implications for users are equally clear. These are–first, a renewed dedication to the fuller exploitation of hardware and software now available; and second, the development internally of a capability to accommodate and digest the technological advancements yet to come.

The degree to which both suppliers and users respond will go a long way in determining just how richly the industry shares in the profits sure to be available, and I would like to look now, at how one of these groups–the industry's users–might respond. General Electric, for instance, has over 1,000 NC machines operating in more than 100 manufacturing locations. Some of the G.E.'s experiences with NC may be helpful to others in generating new levels of productivity and profits.

Before discussing these experiences, it might be helpful if I give you some examples of the various components within General Electric from which they have been drawn.

The first of these is the company's Evendale, Ohio, Aircraft Engine facility, where more than 185 NC machines are probably the highest concentration of NC within one factory anywhere in the world.

At Evendale, one of the principal uses of NC machine tools is that of machining parts for the CF 6 engine used on the DC 10. The outer compressor casings and the integral rotor spool provide examples of engine parts whose present design and configuration were literally impossible before NC.

NC is also used at Evendale to effect dramatic savings in production cycles on such applications as electron beam spot welding. NC positioners cut positioning cycles in this application by a factor of 20 to 1, and it is only because of NC's high-speed positioning capability that the business is able to realize the potential of this new technology and others like laser drilling.

At the company's new steam turbine plant in Charleston, South Carolina, NC is used to reduce cycles and tooling expense in the stub boring of these turbine casings, and the work done in planning for and supporting NC at this plant has been given major credit for a reduction in plant start-up time.

Another plant which achieved fast start up with NC is the company's $110 million Greenville, South Carolina, gas turbine plant. Here, such success was experienced with the 17 NC machines in the division's original plant that its recent expansion there included 25 more NC machines. By using standardized tape format and command codes, the plant is able to run all 25 of these using only two post processors.

At Schenectady, the older turbine manufacturing plants have also invested heavily in NC. Here, these high pressure turbine shells, and these turbine buckets, as well as rotors and other parts, are machined by NC in applications which shorten cycles, reduce tooling expense, and produce better quality.

Success in applying NC at G.E. has not, of course, been limited to high-value, low-volume items, nor has it been limited to machining alone.

At the company's plant in Bloomington, Illinois, where there are 31 NC machines, NC is used to drill holes on printed circuit boards prior to the insertion of electronic components; it is used to insert these components on the boards; and it is used to test many of the department's finished products as well.

The testing done on this solid state logic module tester is of particular interest. The rate of 100 tests per second that is possible on this equipment allows the business to test all modules, completely and accurately, in a cycle which could not have been approached by conventional means. The elimination of human decision and sampling error has virtually eliminated start-up failures in the field, and this provides a new level of quality assurance to customers.

Most manufacturing components in General Electric are using NC, and there are also a number of nonoperating components within the company which have been important to the spread of NC.

Primary among these is the company's Machinery Development Laboratory in Schenectady headed by Dr. W. W. Gilbert. This is a name that is familiar to many of you—he's an NCS member, and he's one of the industry's acknowledged experts in the general area of machining. The way in which Dr. Gilbert and his people help G.E. make NC pay is by conducting early missionary work with new NC equipment, and by selling the benefits of NC to the company's operating components. They have successfully fulfilled this mission by stressing "hands-on" demonstration, by conducting hardware evaluation by way of actual part production, and by supporting the operating components with extensive training and machine support services.

A second such operation is the company's Computer Application Operation; This operation is charged with finding ways of using the company's $250 million worth of installed computers to support NC.

The company's Automation Equipment Operation is active in the area of machining aids and was responsible for the development of a form of adaptive control now used with NC in the company's Schenectady turbine plant.

The focus of suppliers' work should be increasingly directed toward what is needed rather than what is possible.

A company organization which aids in efforts to make NC pay is GENCA—the General Electric Numerical Control Activity. This is an organization of approximately 500 company engineers and is, in effect, G.E.'s internal Numerical Control Society.

There are three basic principles of successful NC use that the varied experiences of these components have developed.

The first of these is that commitment to NC is not enough—it is rather the commitment to make NC pay that really counts.

Second, it is not critical to the success of an NC project that it be solved in a specific way technically. What is important is that the problem does get solved, and in a cost-effective manner.

Finally, the success or failure of any NC project is a direct function of the quality and extent of the advanced planning done for the project, and this includes the planning done for the complementary resources which all NC projects require.

All of these principles are so fundamental and so obvious that they might not even be worth repeating. I can only suggest, however, that adherence to these basic principles will help establish NC more broadly in the nation's over-all manufacturing process.

With this as a backdrop, look now at several ideas concerning successful NC project planning.

I warn you, these ideas, also, will be obvious and fundamental. But they are critical to the profit objective, and for this reason, they merit the renewed attention of all of us.

The first step in the successful planning of any NC project is that of establishing whether or not the problem in question is best solved by NC. The user wants to make money, not chips, and his first question should be: *Will an NC solution help make money?*

The answer to this question is most often found in the answer to two additional questions:

- Have we properly defined our needs?
- Have we thought through fully all of the factors that determine whether NC is the right answer? Have we looked at product design; size and complexity of workpiece; value of workpiece; shape of part to be produced, precision required; quantity to be manufactured, degree of repetition, and the probable impact of these factors on equipment loading, material handling, and factory layout?

And there are other questions, too, once we've established that NC is the correct answer:

- Have we solicited the cooperation of a number of machine builders in reviewing our application and in helping us to optimize machine function?
- After looking at the various options, have we selected the right machine and the right machine builder?
- And have we based this decision on a detailed comparison of the offerings available?

One often makes a better judgment on machine suitability if he worries about function first and price and delivery second. It's not that price and delivery aren't important; obtaining the best of these is imperative once a machine has been selected. Many projects have gone awry, however, when we've looked more at what the machine would cost than at what it could produce.

continued next page

PROFITS continued

Having selected a machine and a supplier, have we thoroughly documented what we, and he, believe to be the equipment purchased, and have we provided for an effective means of establishing that this is what's actually been produced?

Here I'm talking about step-by-step development of agreed-upon, detailed specifications–electrical, hydraulic, and mechanical, as well as agreement on function, design, and construction features. All of these are important, and so are the acceptance test procedures to be followed, and the test equipment to be used.

Attention to all of these factors can save hours of machine debugging time on the factory floor.

And before the machines are shipped, we should ask if the necessary attention has been paid to the physical surroundings that this new investment will occupy:

- proper foundation,
- proper power supply,
- availability of spares,
- availability of tools, and tool and tape storage,
- workpiece mobility,
- operator mobility and competence,
- chip removal, etc.

These may seem to be mundane considerations, but they are essential in obtaining satisfactory and efficient machine performance.

And with regard to tooling and workpiece, are methods and part planning complete? Tools and tapes over the life of the machine are often as expensive as the machine itself, and these must be provided for and protected. They will only be protected if necessary methods–professionally conceived–and proper tooling–professionally planned–are available when the machine is put into production.

And what about parts programs? Are they available and in a language we'll understand? Has provision been made for necessary preprocessors and post processors? Is appropriate computer assistance available to the programmer? Is the programmer himself equal to the task?

Remember that the kind of individual needed for programming is very often not the design engineer who is apt to lose interest once he's mastered the language; you may be better off with a more meticulous and methodical type who's prepared to do some fairly detailed work if that's what's necessary for a successful program.

Another important person is the maintenance man, and the need here, as it is in programming, is to develop a dedicated capability. Chances are this also won't be a professional engineer, but it won't be an average electrician either. To do the job, be sure to get a maintenance man trained in NC–not just the senior man available.

You often make a better judgement on machine suitability if you worry about function first and price and delivery second.

The training need extends to all of those involved in the project–from the manufacturing engineer who plans it, to the machine operators and foremen who will implement it, and to those who will deal with its output–those in production control, those in quality control, and those involved in systems work.

A final need is that of ensuring management support at every level of the organization. NC projects don't run themselves, and without top management support they will not succeed. As Warren Martin of Circle Tool Company put it so well in a recent quote in *Iron Age:* "Every NC machine needs a 'father,' It's not just another tool under a foreman. It needs somebody who really understands."

If we don't get this kind of understanding and support, individual projects won't succeed. And if individual projects don't succeed, then the industry won't succeed in progressing the advancement of its ultimate and justifiable goal–that of making even more dramatic contributions to improvement in the over-all manufacturing process.

But if we get such understanding and support, not only will existing users experience more of the benefits of NC in the decade of the 70s, but these benefits will be, at the same time, made available to more users than ever before.

When this happens and users experience

- better accuracy and repeatability,
- better control of feeds and speeds,
- fewer cutter problems and less down time,
- reduced set ups and cutting time,
- greater time and cost predictability,
- improved capability for meeting commitments,
- reduced investment in floor space and inventory.....

In short, when users experience flexible automation resulting in better quality, better cycles, and increased output at lower cost, better profits, for suppliers and users alike, will go hand in hand, and these will lead, in turn, to the development of new solutions to our manufacturing problems.

The industry's suppliers are already showing that they are prepared to respond, and their recent emphasis on low cost, hard-wired controls, and on more economic offerings of commercial software and support services, are expressive of this. These developments are bringing NC economics within the reach of even the smallest of small shop users; and since shops with fewer than 50 employees account for nearly 70 per cent of the domestic machine tool market, these developments are a major step in solving the industry's over-all market penetration problem.

As this trend continues–as users generally rediscover and exploit the already available benefits of NC, and as suppliers in turn make their new products and concepts as cost effective as those in popular use today, there is no doubt in my mind that this industry will be back on its previous track record of growth–that the theme of your conference, "Profits for the 70s," will become a reality–and that you will have many more anniversary dates to celebrate in the decades ahead.□

Author Robert B. Kurtz is vice president and group executive–Industrial Group, General Electric Company.

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