The rocky Road to the Marketplace

by T. A. Wise
FORTUNE Oct. 1966, p 138

Deciding to put out a new line of computers was tough enough. But later I.B.M. discovered that its troubles were just beginning.

When Tom Watson Jr. made what he called "the most important product announcement in company history," he created quite a stir. International Business Machines is not a corporation given to making earth-shaking pronouncements casually, and the declaration that it was launching an entirely new computer line, the System/360, was headline news. The elaborate logistics that I.B.M. worked out in order to get maximum press coverage—besides a huge assembly at Poughkeepsie, I.B.M. staged press conferences on the same day in sixty-two cities in the U.S. and in fourteen foreign countries---underscored its view of the importance of the event. And the fact that the move until then had been a closely guarded secret added an engaging element of surprise. But it was the magnitude of the new line—Watson called System/360 "a sharp departure from the concepts of the past"—that was really responsible for the reaction that ran through the computer industry. No company had ever introduced, in one swoop, six computer models of totally new design, in a technology never tested in the marketplace, and with programing abilities of the greatest complexity. Once the announcement was made, it is no wonder that, in the scattered locations where I.B.M. plans, builds, and sells its products, there was, on that evening of April 7, 1964, a certain amount of dancing in the streets.

By now, two and a half years later, it would seem that there was good reason for the celebrations. As FORTUNE related in Part I last month, I.B.M. was staking its treasure (some $5 billion over four years) , its reputation, and its Position of leadership in the computer field on its decision to go ahead with System/360. The current rate of shipments of the several models in the series is probably running close to 1,000 computers a month. Authoritative forecasts indicate that, on the basis of orders already on the books, over 26,000 members of the System/360 family will be operating around the world by the end of 1968. If these forecasts are correct, some $10 billion worth of I.B.M.'s new computing equipment will be in the field then. Even allowing for the fact that as many as 10 to 20 percent of the customers now signed up may cancel their orders, the results in hand by the end of this year would stamp the whole 360 venture as very successful.

The final verdict on I.B.M.'s wisdom, however, depends on a series of factors more complicated than the number of shipments. The programing of System/360 is one enormously difficult area and here much remains to be accomplished before the project can be rated a complete success. Moreover, there have been new developments in technology since System/360 was launched in 1964 ; will they enable competitors to leapfrog into something better ? And the managerial and organizational changes that were brought about by the company's struggle to settle on, and then to produce and market, the new line are still having their effects. In each of these several aspects, past, present, and future are closely intertwined.

The rising cost of asking questions

No part of the whole adventure of launching System/ 360 has been as tough, as stubborn, or as enduring as the programing. Earlier this year, talking to a group of I.B.M.customers, Tom 'Watson Jr. said ruefully: "We are investing nearly as much in System/360 programing as we are in the entire development of System/360 hardware. A few months ago the bill for 1966 was going to be $40 million. I asked Vin Learson last night before I left what he thought it would be for 1966 and he said $50 million. Twenty-four hours later I met Watts Humphrey, who is in charge of programing production, in the hall here and said, 'Is this figure about right ? Can I use it?' He said it's going to be $60 million. You can see that if I keep asking questions we won't pay a dividend this year."

Watson's concern about programing, of course, goes back to the beginnings of the System/ 360 affair. By late in 1962 he was sufficiently aware of the proportions of the question to invite the eight top executives of I.B.M. to his ski Lodge in Stowe, Vermont, for a three-day session on programing. The session was conducted by Fred Brooks, the corporate manager for the design of the 360 project, and other experts ; they went into the programing in considerable detail. While the matter can become highly technical, in general I.B.M.'s objective was to devise an "operating system" for its computer line, so that the computers would schedule themselves, without manual interruption, and would be kept working continuously at or near their capacity. At the time it announced System/360, I.B.M. promised future users that it would supply them with such a command system.

Delivery on that promise has been agonizingly difficult. Even though Tom Watson and the other top executives knew the critical importance of programing, the size of the job was seriously underestimated. The difficulty of coordinating the work of hundreds of programers was enormous. The operating system I.B.M. was striving for required the company to work out many new ideas and approaches ; as one company executive says, "We were trying to schedule inventions, which is a dangerous thing to do in a committed project." Customers came up with more extensive programing tasks than the company had expected, and there were inevitable delays and slowdowns. Even today, the difficulties of programing are preventing some users from getting the full benefit from their new machines. By I.B.M.'s own estimates, the company won't have most of the bugs out of programing the larger systems until the middle of 1967—at least a year behind its expectation.

In technology, I.B.M. was also breaking new ground. During the formative years of the decisions about the technology of System/360, a lengthy report on the Subject was prepared by the *ad hoc* Logic Committee, headed by Erich Bloch, a specialist in circuitry for I.B.M. Eventually, the Logic Committee report led to the company's formal commitment to a new hybrid kind of integrated-circuit technology—a move that, like so many other. aspects of the 360 decision, is still criticized by some people in the computer industry, both inside and outside of I.B.M.

The move, though, was hardly made in haste. The whole computer industry had raced through two phases of electronic technology—vacuum tubes and transistors—between 1951 and 1960. By the late 1950's it was becoming apparent that further technological changes of sweeping importance were in the offing. At that time, however, I.B.M. was not very much of a forte in scientific research, its strengths lying in the assembling and marketing of computers, not in their advanced concepts. The company's management at the time had the wit to recognize the nature of the corporate deficiency, and to see the importance of correcting it. In 1956, I.B.M. hired Dr. Emanuel Piore, formerly chief scientist of U.S. naval research. Piore became I.B.M.'s director of research and a major figure in the technological direction that the company finally chose for its System/360.

The cold realities of choice

Under Piore's direction, I.B.M.'s prestige in both pure and applied research rose dramatically. The company gained recognition as a leader in electronics, physics, and mathematics. It made efforts in many directions, including an important inquiry into cryogenics—the behavior of materials at extremely low temperatures. At temperatures close to absolute zero (-459.7°F.) the resistance to electricity of certain metals, such as lead and tin, virtually vanishes. This means that cryogenic computer circuitry could be much faster, and the power required much smaller. Between 1958 and 1961, I.B.M. spent between $10 million and $15 million, including some government funds, in an attempt to perfect a computer technology based on cryogenics ; at one point the company made what some regarded as an alarming laboratory discovery of a cryogenic process that might eventually make the manufacture of computers so cheap that I.B.M.'s profits would become very thin. (Watson turned to his marketing and manufacturing experts to find out what the company might do if this process were perfected. They assured him it was not about to happen.) For a long time some people at I.B.M. remained convinced that cryogenics would revolutionize their company and their industry. But when the company started working toward the practical choice of a technology for System/360, it leaned more heavily on its engineers than on its research scientists, and cryogenics died a sudden death.

In the end, as the report of the Logic Committee showed, the choice narrowed to two technologies. One was monolithic integrated circuitry: putting all the elements of a circuit—transistors, resistors, and diodes- on one chip at one time. The other was hybrid integrated circuitry—I.B.M. rather densely termed it "solid logic technology"—which means making transistors and diodes separately and then soldering them into place. In 1961 the Logic Committee decided that the production of monolithic circuits in great quantities would be risky, and in any case would not meet the schedule for any new line of computers to be marketed by 1964.

There was little opposition to this recommendation initially, except among a few engineering purists. Later, however, the opposition strengthened. The purists believed that monolithic circuits were sure to come, and that the company in a few years would find itself frozen into a technology that might be obsolete before the investment could be recovered. However, the Logic Committee's recommendation on the hybrid approach was accepted ; since that time, Watson has referred to the acceptance as "the most fortunate decision we ever made." But some of the critics, at least, still persist in their disagreement with that judgment : their position is that if I.B.M. had put into monolithic circuits the effort it devoted to the hybrids, there would have been a monolithic success, and both company and industry would be better off.

The secrets circuits hide

The decision to move into hybrid integrated technology accelerated I.B.M.'s push into component manufacturing, a basic change in the character of the company. In the day of vacuum tubes and transistors, I.B.M. had designed the components for its circuits, ordered them from other companies (a principal supplier: Texas Instruments) , then assembled them to its own specifications. But with the new circuitry, those specifications would have to be built into the components from the outset. "Too much proprietary information was involved in circuitry production," says Watson. "Unless we did it ourselves, we could be turning over some of the essentials of our business to another company. We had no intention of doing that." In addition, of course, I.B.M. saw no reason why it should not capture some of the profit from the manufacturing that it was creating on such a large scale.

The company's turn to a new technology jibed neatly with a previous decision made in 1960 by Watson at the urging of the man who was then I.B.M. president, Al Williams, that the company should move into component manufacturing. By the time the decision to go into hybrid circuits was made, I.B.M. already had started putting together a component manufacturing division. Its general manager was John Gibson, a Johns Hopkins Ph.D. in electrical engineering. Under Gibson, the new division won the authority, hitherto divided among other divisions of the company, to designate and to buy the components for computer hardware, along with a new authority to manufacture them when Gibson thought it appropriate.

This new assignment of responsibility was resented by managers in the Data Systems and General Products divisions, since it represented a limitation on their authority. Also, they protested that they would be unable to compare the price and quality of in-house components with those made by an outside supplier if they lost their independence of action. But Vincent Learson, then group executive vice president, feared that if they kept their independence they would continue to make purchases outside the company, and that I.B.M. as a consequence would have no market for its own component output. He therefore put the power of decision in Gibson's hands. I.B.M.'s board, in effect, ruled in Gibson's favor when, in 1962, it authorized the construction of a new manufacturing plant, and the purchase of its automatic equipment, at a cost of over $100 million.

While I.B.M. was making up its corporate mind about the technology for System/360, the delegation of specific responsibilities was going ahead. Learson designated Bob Evans, now head of the Federal Systems Division, to manage the giant undertaking. Under Evans, Fred Brooks was put in charge of all the System/360 work being done at Poughkeepsie, where four of the original models were designed ; he was also made manager of the over-all design of the central processors. The plant at Endicott was given the job of designing the model 30, successor to the popular 1401, which had been developed there. And John Fair-clough, a systems designer at World Trade, was assigned to design the model 40 at the I.B.M. lab at Hursley, England.

Out of the Hursley experience came an interesting byproduct that may have significant implications for I.B.M.'s future. With different labs engaged in the 360 design, it was vital to provide for virtually instant communication between them. I.B.M. therefore leased a special transatlantic line between its home offices and the engineers in England, and later in Germany. The international engineering group was woven together with considerable effectiveness, giving I.B.M. the justifiable claim that the 360 computer was probably the first product of truly international design.

While dovetailing plans for the 360, I.B.M. also became involved at first hand with an international communication system for the processing of information. In 1961, I.B.M. used 28,900 miles of domestic telephone circuitry; by 1966 it was using 380,000 miles, and two voice channels across the Atlantic. On the basis of that volume, I.B.M. last year petitioned the FCC for the right to bypass the common carriers, A.T.&T. and I.T.T., and have direct access to the Comsat satellite. The petition was turned down in July of this year.

But the experience opened a new window to the future for the company. I.B.M. now has the vision of the communication of tomorrow, with machines talking to machines across the oceans. What that will mean in terms of the dollar volume of the market is still conjectural, but I.B.M. feels sure it is a market that does not have to be controlled completely by the entrenched carriers. I.B.M. makes a careful distinction between data transmission—the simple function of carrying electrical impulses—and data transformation, which it defines as the analyzing, correlating, and sorting of those impulses. I.B.M. does not want to be considered merely the manufacturer , of a device that would be only a part of the common carriers' communication system, and so subject to conventional regulations and tariff schedules. It sees itself playing a critical role in a brand-new kind of international data communication, composed of computers that work and talk with each other. And in such a vision compatibility is a necessary element. Compatibility is just what System/360 possesses.

In a tug-of-war, enough rope to hang yourself

Even in a corporation inured to change, people resist change. By 1963, with the important decisions on the 360 being implemented, excitement about the new product line began to spread through the corporation—at least among those who were privy to the secret. But this rising pitch of interest by no means meant that the struggle inside the company was settled. The new family of computers cut across all the old lines of authority and upset all the old divisions. The System/360 concepts plunged I.B.M. into an organizational upheaval.

Resistance came in only a mild form from the World Trade Corp., whose long-time. boss was A. X. Watson, Tom's brother. World Trade managers always thought of European markets as very different from those in the U.S., and as requiring special considerations that U.S. designers would not give them. Initially they had reservations about the concept of a single computer family, which they thought of as fitted only to U.S. needs. But when I.B.M. laboratories in Europe were included in the formulation of the design of some of the 360 models, the grumblings from World Trade were muted. Later A. X. Watson was made vice chairman of the corporation and Gilbert Jones, formerly the head of domestic marketing of computers for the company, took over World Trade. These moves further integrated the domestic and foreign operations, and gave World Trade assurance that its voice would be heard at the top level of the corporation.

The General Products Division, for its part, really bristled with hostility. Its output, after all, accounted for two-thirds of the company's revenues for data processing. It had a popular and profitable product in the field, the 1401, which the 360 threatened to replace. The executive in charge of General Products, John Haanstra, fought against some phases of the 360 program. Haanstra thought the new line would hit his division hard. He was concerned, from the time the System/360 program was approved, about the possibility that it would undermine his division's profits. Specifically, he feared that the cost of providing compatibility in the lower end of the 360 line (which would be General Products' responsibility) might price the machines out of the market. Later he was to develop some more elaborate arguments against the program.

For a while, some parts of I.B.M.'s marketing organization also resisted the new course. The marketers' concern was centered on one aspect of the 360 program: the central processor—i.e., the computer and its memory without any peripheral equipment—would sell for less than those in other I.B.M. lines. Some salesmen assumed that the difference threatened their commission structures. At I.B.M., salesmen are given quotas expressed in points, with one point representing one dollar's worth of additional net monthly rental income. If a salesman receives a quota of 1,000 points, and then manages to persuade a customer to replace equipment renting for $4,000 monthly with something renting for $5,000 monthly, he has met his quota (and earned a commission). Salesmen were haunted by the notion that lower prices would depress commissions. But this fear gradually dissolved, as it became clear that the lower prices for central processors would be more than offset by heavier sales of peripheral equipment—which were implied in the System/360's expanded capabilities.

The battle of San Jose

Long after the company's SPREAD committee had outlined the System/360 concept, and it had been endorsed by I.B.M.'s top management, there were numerous development efforts going on inside the company that offered continuing alternatives to the concept—and they were taken seriously enough, in some cases, so that there were fights for jurisdiction over them. Early in 1963, for example, there was a row over development work at I.B.M.'s San Jose Laboratory, which belonged to the General Products Division. It turned out that San Jose—which had been explicitly told to stop the work—was still developing a low-power machine similar to one being worked on in World Trade's German lab. When he heard about the continuing effort, A.K. Watson went to the lab, along with Emanuel Piore, and seems to have angrily restated his demand that San Jose cut it out. Some people from San Jose were then transferred to Germany to work on the German machine, and the General Products effort was stopped. In the curious way of organizations, though, things turned out well enough in the end: the German machine proved to be a good one, and the Americans who came into the project contributed a lot to its salability. With some adaptations, the machine was finally incorporated into the 360 line, and now, as the model 20, it is probably selling better than any other in the series.

In the fall of 1963, Tom Watson acted in several ways to speed up work on the 360 program. First of all, he announced the abolition of the corporate management committee, a group of top executives functioning as the chief policy makers of the company. While the move was not formally linked to the 360, the fact was that Watson had become impatient with the excessively crowded agenda of the committee during the years when the 360 was being developed. He believed that too many of the vital decisions about the program were being "bucked upstairs" when they could have been settled at a lower level; abolishing the committee would forte these earlier settlements.

Watson also made some new management assignments that reflected the impact of the 360 program on the corporation. Learson was shifted away from supervising product development and given responsibility for marketing, this being the next phase of the 360 program. Gibson took over Learson's former responsibilities. The increasing development of I.B.M. into a homogeneous international organization was reflected in the move up of A.K. Watson from World Trade (he is now corporate vice chairman); he was succeeded by Gilbert Jones, former head of domestic marketing. Piore became a group vice president in charge of research and several other activities.

One reason for Watson's interest in speeding up the 360 program in late 1963 was an increasing awareness that the I.B.M. product line was running out of steam. The company was barely reaching its sales goals in this period. Some of this slowdown, no doubt, was due to mounting rumors about the new line. But there was another, critical reason for the slowdown: major customers were seeking ways of linking separate data-processing operations on a national basis, and I.B.M. had limited capability along that line. Finally, I.B.M. got a distinctly unpleasant shock in December, 1963, when the Honeywell Corp. announced a new computer. Its model 200 had been designed along the same lines as the 1401—a fact Honeywell cheerfully acknowledged—but it used newer, faster, and cheaper transistors than the 1401 and was therefore priced 30 percent below the I.B.M. model. To make matters worse, Honeywell's engineers had figured out a means by which customers interested in reprograming from an I.B.M.

1401 to a Honeywell 200 could do so inexpensively. The vulnerability of the 1401 line was obvious, and so was the company's need for the new line of computers.

It was around this time that some I.B.M. executives began to argue seriously for simultaneous introduction of the whole 360 family. There were several advantages to the move. One was that it would have a tremendous public relations impact and demonstrate the distinctive nature of I.B.M.'s new undertaking. Customers would have a clear picture of where and how they could grow with a computer product line, and so would be more inclined to wait for it. Finally, there might be an antitrust problem in introducing the various 360 models sequentially. The Justice Department might feel that an I.B.M. salesman was improperly taking away competitors' business if he urged customers not to buy their products because of an impending announcement of his own company's new model. I.B.M. has long had a company policy under which no employee is allowed to tell a customer of any new product not formally announced by the management. (Several employees have, in fact, been fired or disciplined for violating the rule.) Still, introducing a long line of computers in sequence might put pressure on salesmen, many of whom would be closely questioned by anxious customers, to violate the rule. Announcing the whole 360 line at once would dispose of the problem.

Learson stages a shoot-out

Beginning in late 1963, then, the idea of announcing and marketing the 360 family all at once gained increasing support. At the same time, by making the 360 program tougher to achieve, the idea gave Haanstra some new arguments against the program. His opposition now centered on two main points. First, he argued that the General Products manufacturing organization would be under pressure to build in a couple of years enough units of the model 30 to replace a field inventory of the 1401 that had been installed over a five-year period. He said that I.B.M. was in danger of acquiring a huge backlog, one representing perhaps two or three years' output, and that competitors, able to deliver in a year or less, would steal business away.

Haanstra's other objection in this period related especially to the 360-30, a model that I.B.M. hoped to sell heavily to its old 1401 customers. The trouble was, Haanstra said, that the 360-30 was noncompatible with the 1401; meanwhile, Honeywell's 200, which was being sold with that company's new reprograming techniques, might tempt as many as three-quarters of the 1401 users—unless I.B.M. extended and improved its 1401 program. Specifically, he proposed a modernized version, using advanced transistor technology, the 1401-S.

But Haanstra's argument was countered to some extent by a group of resourceful I.B.M. engineers. They believed that the so-called "read-only" storage device could be adapted to make the 360-30 compatible with the 1401. The read-only technique, which involved the storing of permanent electronic instructions in the computer, could be adapted to make the model 30 act like a 1401 in many respects: the computer would be slowed down but the user would be able to employ his 1401 program. I.B.M. executives had earlier been exposed to a read-only device by John Fairclough, the head of World Trade's Hursley Laboratory in England, when he was trying (unsuccessfully) to win corporate approval for his Scamp computer.

Could the device really be used to meet Haanstra's objections to the 360-30? To find out, Learson staged a "shoot-out" in January, 1964, between the 1401-S and the model 30. The test proved that the model 30, "emulating" the 1401, could already operate at 80 percent of the speed of the 1401-S and could improve that figure with other adaptations. That was good enough for Learson. He notified Watson that he was ready to go, and said that he favored announcing the whole System/360 family at once.

"Going . . . going . . . gone!"

Haanstra was still not convinced. He persisted in his view that his manufacturing organization probably could not gear up to meet the production demand adequately. On March 18 and 19, a final "risk-assessment" session was held at Yorktown Heights to review once again every debatable point of the program. Tom Watson Jr., President Al Williams, and thirty top executives of the corporation attended. This was to be the last chance for the unpersuaded to state their doubts or objections on any aspect of the new program—

patent protection, policy on computer returns, the company's ability to hire and train an enormous new work force in the time allotted, etc. Haanstra himself was conspicuously absent from this session. In February he had been relieved of his responsibilities as president of the General Products Division and assigned to special duty—monitoring a project to investigate the possibility of I.B.M.'s getting into magnetic tape. (He is now a vice president of the Federal Systems Division.) At the end of the risk-assessment meeting, Watson seemed satisfied that all the objections to the 360 had been met. Al Williams, who had been presiding, stood up before the group, asked if there were any last dissents, and then, getting no response, dramatically intoned, "Going .. going . . . gone!"

Work on the pricing of the 360 line had already begun. I.B.M.'s marketing forecasters go through what is termed a "pricing loop" in determining the optimal price of their products. A price is first set tentatively on a model. Then the marketing organization gives an estimate of the number of models it can sell at that price. This estimate is fed back to the manufacturing group, which must itself estimate whether, given that volume of production, manufacturing costs might be lowered enough to warrant a lower price. This whole cycle is repeated several times, until the most desirable balance between price and volume is achieved. In the case of the 360, the pricing sessions were fairly hectic. One participant recalls, "We reviewed the competitive analysis for perhaps the fifteenth time. We had to take into consideration features that could be built in later with the turn of a screwdriver but that were not to be announced formally. We were pulling cost estimates out of a hat."
he April 7, 1964, announcement of the program unveiled details of six separate compatible computer machines; their memories would be interchangeable, so that a total of nineteen different combinations would be available. The peripheral equipment was to consist of forty different input and output devices, including printers, optical scanners, and high-speed tape drives. Delivery of the new machines would start in April, 1965.

The nature of the risk

With the April 7 announcement, I.B.M. was at last irrevocably committed to the risks that it had always recognized to be inherent in the 360 program. But in the summer of 1964 management was confident that it had made the right decision and had ample resources to see the program through. It was so confident, in fact, that it decided I.B.M. did not need all the cash it had on hand. Cash balances had been increasing for several years, and were approaching $1 billion at the end of 1963; meanwhile, there had been some trend toward increased purchases of equipment instead of rental, and so it was assumed that the need for cash would de line. For these reasons the company decided to prepay $10 million of loans from the Prudential Insurance Co., bearing an average interest rate of 3 1/2 percent; Prudential waived the stipulated premium for prepayment. This stands as one I.B.M. decision about which there is, in retrospect, no controversy—it was a mistake. In 1966 the company has had to establish bank lines of credit totaling the same $160 million, and has to pay about two percentage points more for any of the funds that are used.

The basic announcement of the new line brought a mixed reaction from the competition. The implication that the 360 line would make obsolete all earlier equipment was derided and minimized by rival manufacturers, who seized every opportunity to argue that the move was less significant than it appeared. I.B.M.'s new technology was criticized for being less than pure microcircuitry. The competition also voiced doubts that I.B.M. could achieve any meaningful degree of compatibility in its line; that was unfeasible, they said, and even if achieved, it would be uneconomic for many customers.

Despite these depreciatory words, the competition was concerned enough about the System/360 to respond to its challenge on a large scale. During the summer of 1964, General Electric announced that its 600 line of computers would have time-sharing capabilities. The full import of this announcement hit I.B.M. that fall, when M.I.T., prime target of several computer manufacturers, announced that it would buy a G.E. machine. I.B.M. had worked on a time-sharing program back in 1960 but had abandoned the idea when the cost of- the terminals involved seemed to make it uneconomic. G.E.'s success caught I.B.M. off base and in 1964 and 1965 it was scrambling madly to provide the same capability in the 360 line. Late in 1964, R.C.A. announced it would use the pure monolithic integrated circuitry (i.e., as opposed to I.B.M.'s hybrid circuitry) in some models of its new Spectra 70 line. This development probably led to a certain amount of soul-searching at I.B.M.

In- the end, however, I.B.M. seems to have decided that the threats posed by these new entries in the market were not disastrous. The company felt that the turn to monolithic circuitry did not involve capabilities that threatened the 360 line; furthermore, if and when monolithic circuitry ever did prove to have decisive advantages over I.B.M.'s hybrid circuitry, the company was prepared—the computers themselves and some three-quarters of the component manufacturing equipment could be adapted fairly inexpensively to monolithics. As for time sharing, any anxieties I.B.M. had about that were eased in March, 1965, when Watts Humphrey, a systems expert who had been given the assignment of meeting the time-sharing challenge (he is a nephew of President Eisenhower's Treasury Secretary, George Humphrey), got the job done.

The competitive challenge and its own new capabilities led I.B.M. to announce some additions to the 360 line in 1964 and 1965. One important addition was the model 90, a supercomputer type, designed to be competitive with Control Data's 6800. Another was the 360-44, designed for special scientific purposes. Also, there was the 360-67, a large time-sharing machine. Another, the 360-20, represented a pioneering push into the low end of the market. None of these are fully compatible with the models originally announced, but they are considered part of the 360 family.

The flying suitcase squad

It looked, at this point, as if the 360 program was well under control. Then some quite unforeseen troubles broke out in the manufacturing operation. One of the steps in making semiconductors was accomplished by an evaporation process, and the company had used small-capacity evaporators to test the technique. But when large-capacity evaporators were introduced to meet mass-production requirements, the I.B.M. engineers at East Fishkill, New York, ran into some problems, which had to do with metallurgical changes that took place in the larger units. Production at East Fishkill came to a virtual standstill. The company immediately rounded up all the smaller evaporators it could find and used them to work production back up to about 50 percent of the original goal. By the end of 1965 the metallurgical problems were finally solved—but by that time the original delivery schedule was unsustainable. I.B.M. had intended to deliver 1,000 of the new computers by December 31 but settled for 837.

Production of the 360 line was also held up by a maddening series of shortages. There were, for example, critical shortages of epoxy glass, copper laminate, and contact tabs. The tabs carry the connection between the printed circuits and the modules. Manufacturers of these tabs were scattered around the eastern part of the U.S., and none of them were prepared for the kind of demand I.B.M. was unleashing in their markets. In some periods of acute tab shortage, teams of I.B.M. engineers were being yanked off their jobs and sent to work with the suppliers to expedite production. I.B.M. representatives suddenly began appearing at tab plants late in the evening or early in the morning, with suitcases. They would pack all the tabs they could and then fly back to Endicott to keep the production line moving.

Around mid-1965, however, the company gradually became aware that production problems were not its only, or even its greatest, obstacle to getting the 360 program on schedule. While there had been no disposition to underrate the technical difficulties in preparing the programing, no one, it appears, foresaw the appalling management problems that would be associated with them. Part of the management problem was that programers who were desperately needed to develop improved software for the 360 line all during 1963 and 1964 were still spending a great deal of time improving the programs associated with the company's older computers. In any case, there was no real yardstick by which management could gauge the time and manpower required to develop the software for a unique venture like the System/360. Early this year the burden of this problem was thrust on Watts Humphrey, fresh from his triumph on time sharing.

The first thing Humphrey did was to order a complete review of all proposed programs; the second was to eliminate some of the more elaborate functions that had been promised. In I.B.M.'s rather euphemistic terminology, some thirty-one technical capabilities were "decommitted." This move helped to break one bottleneck, but it represented only a minor gain in the total software campaign.

I.B.M. had several managers trying to get the 360 program back on the track in 1964-65. Gibson, who had succeeded Learson in the job, was replaced late in 1964. His successor. Paul Knaplund, lasted about another year.

Sharing the bad news

In March, Tom Watson Jr. visited California to address a meeting of "Share," which is a group of users of I.B.M. equipment who meet from time to time to exchange information and opinions about I.B.M. products. Some of the Share members had helped I.B.M. develop its new 360 computer language, and Watson doubtless felt a special obligation to be candid to the group; in any case, he made no effort to paper over his company's problems. Some of his listeners were then grumbling about the postponements of hardware delivery announced the previous October. Watson acknowledged the dissatisfaction of his customers, referred to the problems with software, and even conceded that the momentous decision to announce the entire 360 package at once in April, 1964, may have been "ill advised."

A month later there was another unscheduled development. Watson surprised the financial community by asking his stockholders for $371 million of equity capital. This financing partly reflected the needs that arose out of heavy demand for the 360 line, and in a sense, therefore, it was good news for the stockholders. In the prospectus, however, there was one item of unalloyed bad news: the company had suffered heavy setbacks at the high end of the 360 line—i.e., in its efforts to bring forth a great supercomputer in the tradition of Stretch. It was writing off $15 million worth of parts and equipment developed specifically for the 360-90.

There were signs at about this time that the 360 program was still generating major reshufflements of divisions and personnel. A new management committee had been formed. the corporate staff had been split into two sections, each leaded by a group vice president. Dr. Piore had been freed from operational duties and responsibilities and given a license to roam the company checking on just about all technical activities. Some of his former duties are now in a division headed by Eugene Fubini, a former Assistant Secretary of Defense and the Pentagon's deputy director of research and engineering before he joined I.B.M. in 1965. Fubini was one of the first outsiders ever brought into the company at such a high executive level (he is a group vice -president); his appointment would seem to confirm the continuing rise in influence of the technical men. Another change represented a comeback for Stephen Dunwell, who had managed the Stretch program and had been made the goat for its expensive failure to perform as advertised. When I.B.M. got into the 360 program, its technical men discovered that the work done on Stretch was immensely valuable to them; and Watson personally gave Dunwell an award as an I.B.M. fellow (which entitles him to work with I.B.M. backing, for five years, on any project of his choosing).

Still another change involved a new management review committee composed of the two Watsons, Learson, and Williams, which was created to help the chief executive run the corporation. Williams, who long had been planning to retire at fifty-five, was prevailed on by Watson to stay as chairman of the executive committee. Finally, Learson, the man who had sparked the 360 from the outset, was named president.

The future of a line

System/360 has undergone many changes since the concept was originally brought forth back in 1962 and even since Watson's announcement in 1964. Today nine central processors are being offered in the 360 line; some of them have memories that are much faster than those originally offered. The number of input-output machines jumped from the original forty to over seventy.

These changes should not be viewed as surprising because the 360 family was designed to be adaptable to new technologies and new kinds of peripheral equipment, and has been made adaptable to time sharing. It is still unclear how much of the equipment will ultimately provide this feature. I.B.M. estimates that time sharing will account for about 30 percent of the computer market; other manufacturers think it may take over the whole market.

To date, the 360 program seems, with one large reservation, to be a considerable success. The reservation concerns programing, where a lot of problems are yet to be licked. The company is currently investing very heavily in money and manpower to get them licked : some 2,000 programers and "support personnel" are on the job, and the cost of this effort may run over $200 million.

The payoff on the 360 program will take years to measure, of course. The payoff will involve not only direct System/360 orders (which have been pretty breathtaking so far), but the entire expansion of computer applications implicit in the line's burgeoning capabilities. The program has pushed I.B.M. itself into feats of performance in manufacturing, technology, and communications that its own staff did not believe were possible when the project was undertaken. Because of the 360, the company is a more sophisticated and more thoroughly integrated organization than it was in 1962.

At the same time, the massive difficulties associated with the project, and the retreats from some of the original goals, have led many businessmen to see I.B.M. in a new light. The difficulties" have done something to that extraordinary I.B.M. mystique of success. The mystique is probably gone for good —although the successes may just go on becoming greater and greater.

END

You Can't Enjoy a Computer without a Program

I.B.M.'s new computer line covers a wide range of configurations and options for the customer—so wide a range, in fact, that I.B.M. employs over 1,000 highly paid people to turn out instructions for the functions of the program of the operating system. The programers sit in cubicles in I.B.M. offices around the world, and think out the logical sequence of steps the computer must follow if it is to process programs most efficiently. As the number of instructions mounts, the need for coordination grows more intense, new concepts are introduced, and the opportunities for misunderstandings and mistakes are compounded. But such difficulties are unavoidable when the functions of the computer become so varied and complex.

The illustration at the left shows the six major steps involved when any computer provides the solution to a problem—even one that is relatively simple compared to the tasks the computer is capable of taking on. Here the computer is asked to calculate monthly and yearly salaries from a compilation of weekly salaries. In the first move (A) a programer writes down the assignment on a coding sheet, in this case in an algebraic language called FORTRAN. The FORTRAN instructions are then punched out on cards (B), and fed into the computer. The FORTRAN compiler (C) produces the machine code (D), which starts the central processor (E) working. The answers provided by the processor are then printed out (F).

The diagram at the right illustrates how the 360's operating system schedules and directs the solution of the salary computation problem. This system is roughly analogous to a library of manuals that the computer reads for instructions as it carries out a job. More than a million and a half instructions are already written on the "pages" of these manuals, and by the time the programing is completed the number may have tripled.

When the salary-computation problem is fed into the computer, the control cards alert the operating system. The heavy black line shows how the Control Program in the box reacts to these instructions. The control cards activate the Job Management facility (orange) where a *reader-interpreter* "reads" the cards and determines that a FORTRAN compiling program must be executed. Information about the locations of such programs is stored in the *directories;* the dotted lines indicate how subsidiary facilities keep in touch while the main job is moving along. The reader-interpreter copies the salary information and stores it as an *input data set.* The input *job queue,* meanwhile, stacks this new task in line with others waiting to be processed.

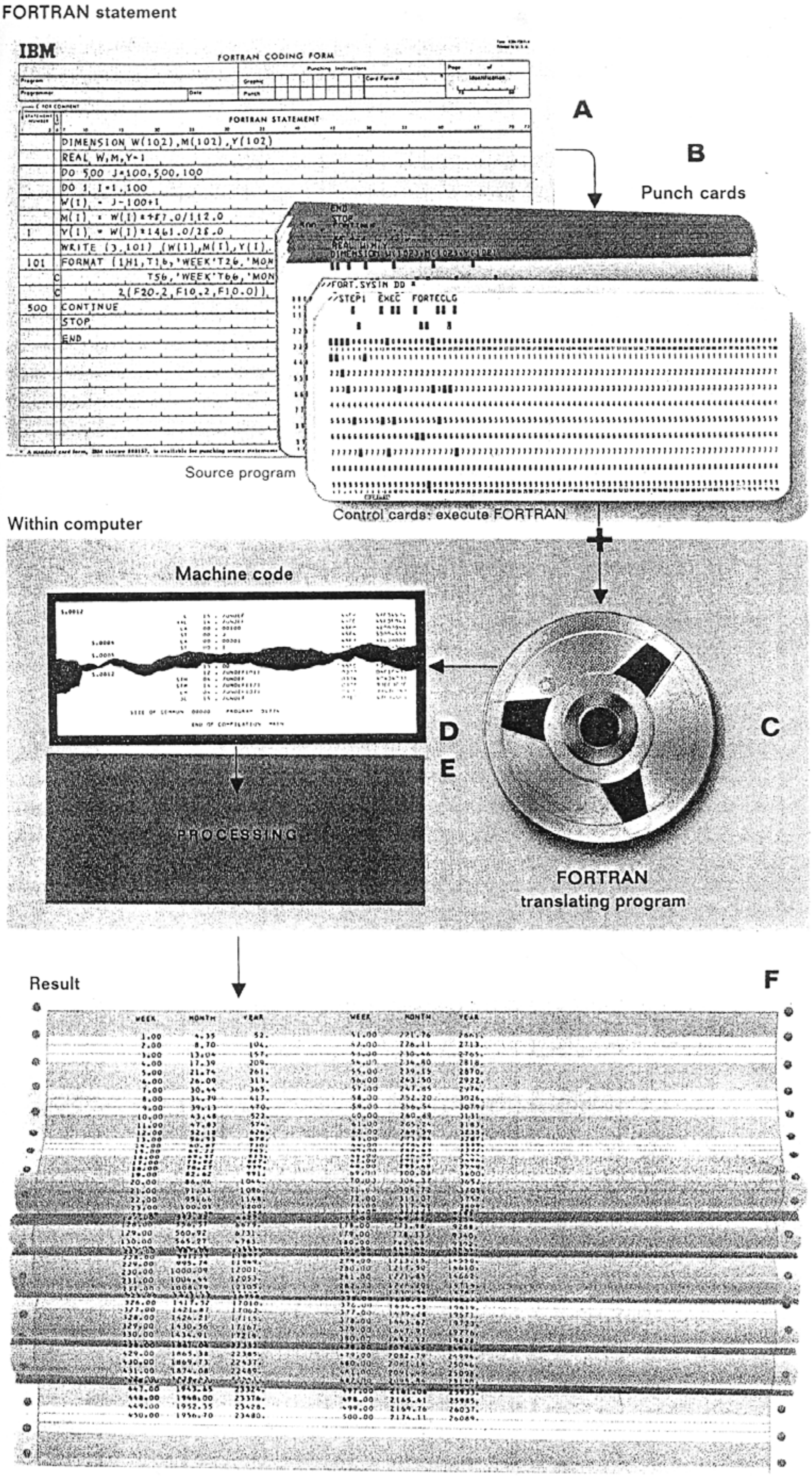
The *initiator* checks on which job has the highest priority and alerts the Task Management section (yellow) to stand by. It also signals *getmain,* asking that the computer's memory or a portion of it be made available for use by a program en route, and notifies the *input/output* devices of a coming demand on their services.

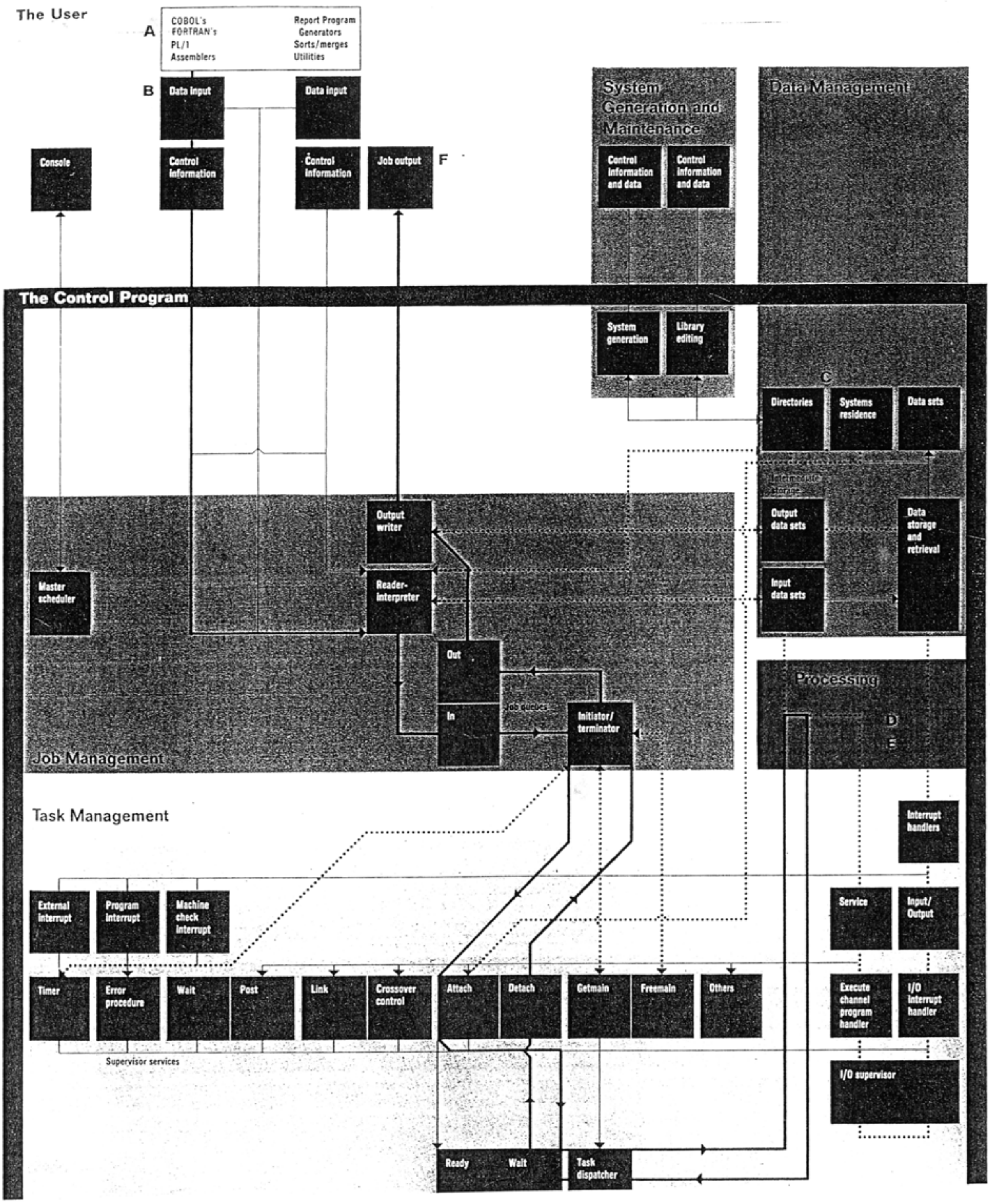
Then the actual processing begins. The *attach* section reaches over to the Data Management section (blue) and brings the FORTRAN compiler into the Processing section (red). It also places the job in the *ready queue* from which the *task dispatcher* evaluates its priorities and forwards it to Processing. After the translation is made and the problem is solved, the monthly and yearly salaries are stored as *output data sets.*

Leaving the Processing section the completed assignment detaches its request from the ready queue promptly freeing its allotted core storage *(freemain).* Then the results are retrieved from the output data sets and printed.

While this comparatively simple program is being processed, it would also be possible to process several other programs of varying priorities. That capability, of course, is the great advantage of System/360 over its less elaborate predecessors.

PROBLEM: *Compute monthly and yearly salaries from weekly salaries*





The User
A
COBOL's
FORTRAN's
PL/1
Assemblers
Report Program
Generators
Sorts/merges
Utilities
B
Data input
Data input
Console
Control information
Control information
Job output
F
System Generation and Maintenance
Control information and data
Control information and data
Data Management
The Control Program
System generation
Library editing
C
Directories
Systems residence
Data sets
Output writer
Output data sets
Data storage and retrieval
Master scheduler
Reader-interpreter
Input data sets
Out
In
Job queues
Initiator/terminator
Processing
D
E
Job Management
Task Management
Interrupt handlers
External interrupt
Program interrupt
Machine check interrupt
Service
Input/Output
Timer
Error procedure
Wait
Post
Link
Crossover control
Attach
Detach
Getmain
Freemain
Others
Execute channel program handler
I/O interrupt handler
Supervisor services
I/O supervisor
Ready
Wait
Task dispatcher