WORK FLOW AND HUMAN RELATIONS

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THE "human relations" of men at work constitute a large and complex subject, many aspects of which have been studied and written about and many aspects of which still remain to be analyzed, let alone recognized for what they are. Although we should never lose sight of the fact that all the forces which control the relations between persons and hence the efficiency of workers are always interacting and interdependent, for purposes of understanding it is necessary to separate out one or two at a time and treat them as if they were phenomena in their own right. One such phase of the subject is the influence of the work flow, which practical men like engineers have thought about and taken into account, at least intuitively, but which has been neglected in the systematic investigations of professional social scientists.

It is the purpose of this article to report some of the findings of several months of field work during 1946 and 1947 in Plant No. 1 of the International Business Machines Corporation, Endicott, New York.[1] Here, among a workforce which had expanded from 3,500 in 1940 to 7,000 in 1947, it was possible to see clearly the importance of the work flow (and of course other factors as well) and to note definitely the different effect on human relations that resulted when the work flow was organized differently.

Background

What is meant by work flow? Obviously the operations of most people in a factory follow a definite sequence. Sales orders are processed by production planners, and their plans are in turn translated into actual materials, which then are bought, processed, assembled, and finally shipped. Actually, of course, the sequence is seldom quite so simple; production may anticipate orders, finished parts may be bought from outside, there may be a period of warehousing before shipping, and so on. But there is in each plant a characteristic sequence of operations which make up what we call the work stream. Papers, plans, materials, parts, and semifinished assemblies, as they are being processed by people, flow along this stream. And all the workers engaged in such processing may, as suggested by Professor C. M. Arensberg of Columbia University, be thought of as tied together by a chain of work-flow relationships.

Indeed, it is the thesis of this article that a knowledge of these work-flow relationships is as essential to a thorough understanding of human relations in any factory as is the more common concern with supervisory and staff relation-

[1] Other findings of the investigation, made under the direction of Charles R. Walker, have been reported in the authors' *Human Relations in an Expanding Industry* (New Haven, Yale University, Labor and Management Center, 1948).

ships. Although the work flow is perhaps not so spectacular as the hierarchy of relationships making up the "chain of command," experience shows that its proper functioning is just as necessary for the maintenance of good morale, not to mention efficient production.

To understand the flow of work in the plant we investigated, we found it useful to think in terms of a river system. Raw materials, orders, and engineering blueprints all start, so to speak, at the headwaters of the main stream or its tributaries. Unfinished materials and parts, which are to form the final product, flow downstream from operator to operator, from section to section, from division to division, until they are assembled, packed, and shipped at the stream's end.

Such a picture has several advantages. It enables one to visualize clearly (and also to plot graphically) whatever an individual contributes to the work flow at the physical spot where his contribution is made — whether he be a production planner who processes the papers necessary for planning the flow of parts or a machine operator processing actual parts.

EXHIBIT I is a simplified diagram of work flow at the Endicott Plant of the International Business Machines Corporation (IBM). It outlines the whole sequence of operations performed from the time salesmen send in orders till the final products, chiefly accounting machines and time clocks, are shipped to the customer. This sequence represents the progressive flow of *materials* and also of *papers* (i.e., principal plans, records, and so forth) along what we have called the *main work stream.*

In addition to the main work stream, a sequence of purchasing operations together make up one tributary stream and a sequence of engineering operations together make another such tributary. To show the purchasing tributary in full, with its interconnections to various operations along the main work stream, would be so complicated as to confuse the picture. However, the engineering tributary, including the functions of designing new machines, improving old ones, and designing and manufacturing necessary new tools, is included in EXHIBIT I and separately pictured in some detail in EXHIBIT II.

Technical Changes Preceding the Investigation. During the period 1940 to 1947 the plant had doubled in size from 3,500 to 7,000 employees. But despite this large increase in numbers of new employees, along with the general unsettling conditions of the war and postwar periods, the evidence is that productivity per man-hour had increased and plant morale had improved.[2]

Our investigation suggested that much of the reason for improvement in both productivity and employee morale could be traced to a thorough reorganization of the work flow. For example, in 1947 interruptions in the work flow had ceased whereas previously in 1940 "hold-ups" in production were not uncommon because the right part failed to reach the right place at the right time. As a result, tried and proved work routines were upset, and human frustrations were frequent. Workers were often switched to emergency jobs, for example, and supervisors found themselves bogged down in details of determining emergency priorities and schedules. With the smoothing out of the flow of work, these human frustrations largely disappeared.

[2] Ibid., Chapter I, p. 9 ff.

Several interconnected changes in organization helped without doubt to bring about this improvement: (1) Previously a job-shop system had been in operation whereby units, instead of flowing progressively from one operator to the next, were frequently returned to a central storeroom. This was replaced by a progressive assembly system whereby units were progressively built up by passing them from operator to operator without returning to a central storeroom. (It should be pointed out, in this connection, that at IBM papers, parts, and partially assembled units flow along at a tempo largely determined by the individual operators themselves and that the work, by and large, requires considerable skill. This is in contrast to the moving belt of an automobile assembly line with its repetitive jobs requiring little skill.) (2) To facilitate the functioning of the progressive assembly line, a new layout was installed bringing sequential operations conveniently close together physically and eliminating much multiple handling and crisscross trucking. (3) Schedules, which were often ignored in 1940, were strictly observed in 1947.

In the present article we shall enlarge neither on these technical changes nor on the human frustrations which arose in 1940 because the flow of work was erratic. Rather we shall discuss the significance of three specific changes concerned with reorganizing persons along the work stream. Apparently these changes likewise were closely related to improvements in morale. They fall under the following three headings: (1) the ratio of supervisors to workers, (2) the horizontal distribution of authority along the work stream, and (3) the level at which work flows and the level at which it is coordinated.

Ratio of Supervisors to Workers

Early observation in our study of work flow at IBM indicated that in 1947, despite a doubling in the size of the factory's personnel, *fewer persons* were needed to coordinate a far *larger volume of work*. To verify this observation and to explore its significance, it was necessary to define work flow more precisely and then to determine in detail what sections of the factory's personnel belonged to it.

For the purpose of analysis, people were classified as being in work-flow operations if they (1) physically handled materials in the flow, (2) physically handled the papers used in planning or expediting the flow of materials, or (3) directed any person or group in the two previous categories. Based on this classification about 90% of the factory personnel at IBM were found to be directly involved in work-flow operations. The remainder were engaged in servicing the people or the machines in the work flow; typical examples are the cost accountants and the maintenance men.

In making this major division of the workforce, and in calculating the total number of those engaged and those not engaged in the work flow, we have taken as our unit the *section*. A section is a work group with a numerical designation assigned by the management, composed usually of ten or more persons performing a particular function and supervised by a foreman. We have counted sections as part of the work flow if most of the men in them performed work-flow functions as already defined (i.e., physically handled the goods, and so on). Using this definition and exercising judgment in the classification of borderline cases, we differentiated roughly 58 sections in 1940, with

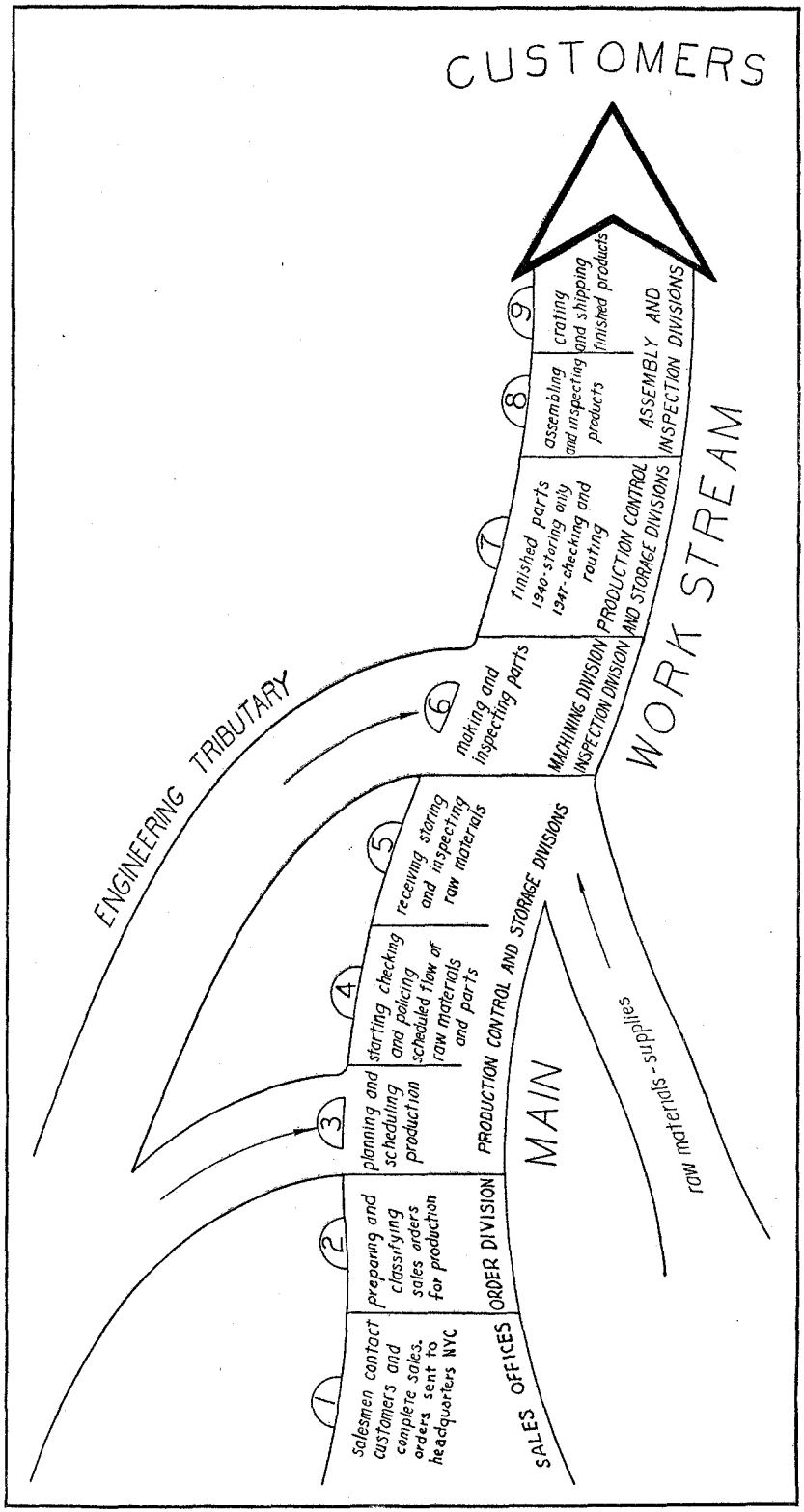


EXHIBIT I. THE WORK FLOW – MAIN WORK STREAM

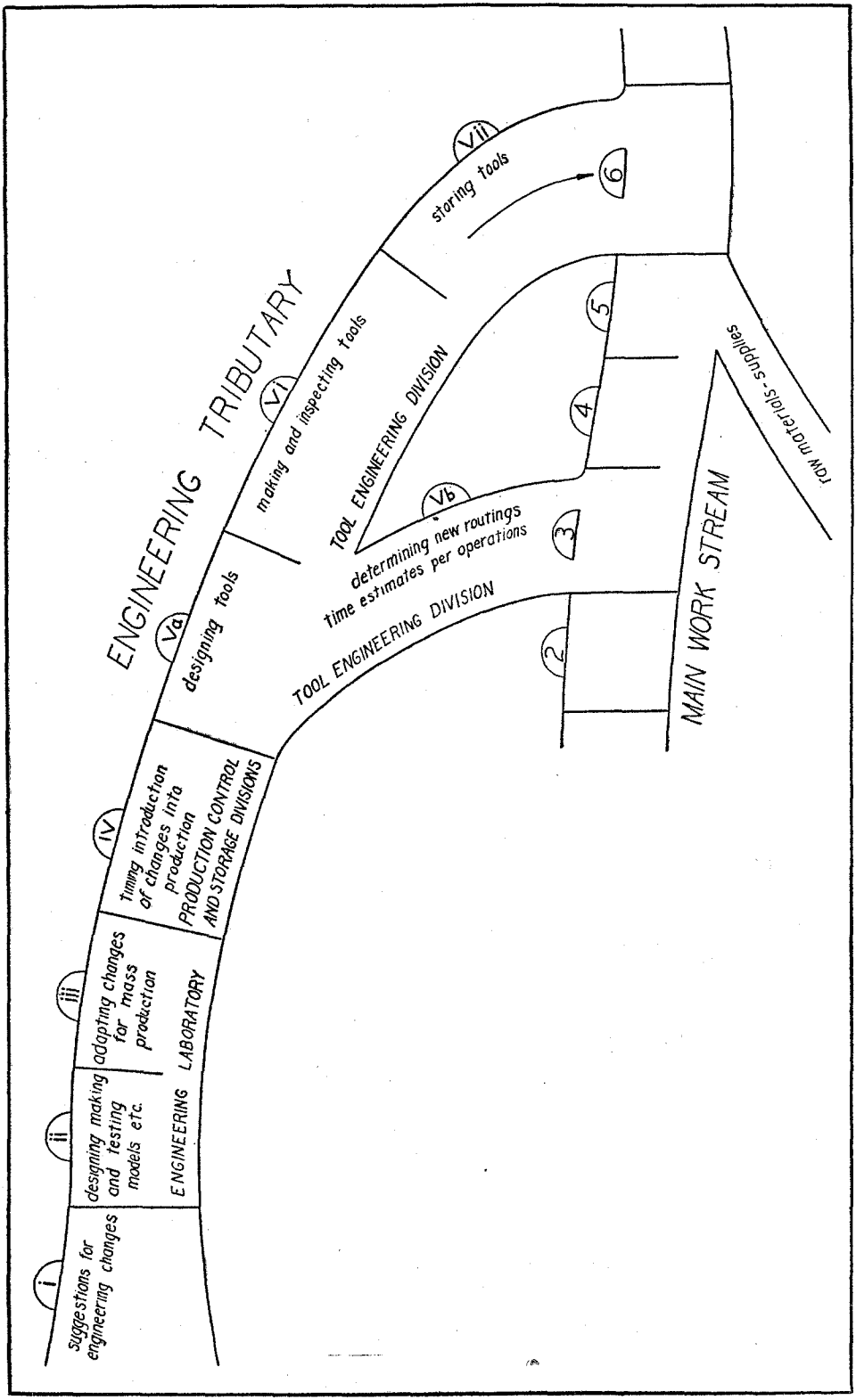


EXHIBIT II. THE WORK FLOW — ENGINEERING TRIBUTARY

a workforce of 3,094, and 161 sections in 1947, with a workforce of 6,309. (This excludes the Engineering Laboratory and sections engaged in processing spare parts for the field offices.)

Superficially it might seem that the new work-flow situation involving progressive assembly demanded proportionally more than half again as much supervision as required by the old method. Adding up the foremen and all higher supervisory personnel, we found that their number had increased from 71 in 1940 to 186 in 1947, or 162%, whereas the total personnel along the work stream had increased from 3,094 to 6,309, or 104%.

These figures, however, are misleading, since they disregard the "keymen" who actually exercised a certain supervisory role in 1940. Under the 1940 setup, foremen had less contact with their men because (1) they supervised far more workers than in 1947 and (2) they were investigating technical and other problems that continually interrupted the smooth flowing of work. Partially by default, therefore, large numbers of straw bosses or subforemen emerged who in fact assumed much authority in supervising workers. But by 1947 the position of keyman had been eliminated, and now only the foreman has the authority to supervise or discipline workers. He may have instructors to help him train operators, but these instructors exercise no supervisory role, and workers are encouraged to discuss all personnel problems with their foreman.

Although unfortunately there are no available figures to indicate the number of keymen along the whole work stream in 1940, figures do exist for the two main manufacturing departments (later, divisions), Machining and Assembly. (Sections either transferred in or out of Machining or Assembly between 1940 and 1947 are not counted.) Here total nonsupervisory personnel more than doubled – from 1,763 in 1940 to 3,934. In contrast, after allowance is made for the keymen in 1940, the supervisory personnel showed virtually no increase at all – 92 in 1940 and 96 in 1947 – an addition of only *four persons*!

In other words, in 1947 roughly the same number of supervisors were required to coordinate more than twice the number of men and twice the amount of work. From the standpoint of human relations, the significance of this fact is great. *It signifies at the very least a marked reduction in potential human points of friction along the flow of work.*

This simple numerical comparison in supervisory ratios along the flow of work rests upon or is made possible by a variety of changes, technical and organizational, which practically eliminated "hold-ups" or serious interruptions in the flow of work. It rests obviously on the new layout of the factory, which meant the elimination of multiple handling and of crisscross trucking between floors. It rests also upon a better and more timely system of scheduling. It reflects the fact that the job of getting the "right part to the right place at the right time" is now accomplished as a matter of routine by a clerical force within Production Control. In short, it may be said to be a quantitative translation of the qualitative observation that a smoother work flow means smoother human relations.

Horizontal Distribution of Authority

The second kind of organizational change we are considering concerns the

horizontal distribution of authority over the various operations making up the work flow. Specifically this pertains to the authority of the divisions which are the largest units into which the plant is subdivided and which are independent in the sense that their heads report directly to a plant manager. Let us picture the way in which the authority of each of the divisions (distinguished by different shadings) is superimposed on the sequence of operations along the main work stream and along the engineering tributary. EXHIBIT III gives the situation in 1940; EXHIBIT IV, that in 1946. Comparison of the two shows the change that has occurred. (The year 1946 has been chosen in place of 1947, for it affords a more clear-cut comparison with 1940. In 1946 there was one division head of Assembly; though he was called an assistant superintendent, he devoted most of his attention to managing the assembly operations. By 1947 there were four division heads of Assembly reporting directly to a plant manager.)

Between 1940 and 1946 three significant moves were made in changing this pattern of supervisory jurisdiction. All three resulted in eliminating instances of divided authority, and there is evidence that each to a greater or lesser extent resulted in more efficient operation and better employee morale. Let us look at them briefly:

(1) In 1940, the function of production engineering was performed in two places on the engineering tributary under two separate authorities: operation iiib was under the Manufacturing division of the plant, and operation iiia was not under the jurisdiction of the plant at all but under the Engineering Laboratory. (The head of the laboratory and the plant manager both reported directly to New York headquarters.) It is not surprising that misunderstandings sometimes arose over the separation of this responsibility. Often persons in both groups would be working on the same problem at the same time independently of each other.

By 1946, operation iiib had been eliminated, or rather the personnel were transferred to operation iiia, and thus the function of production engineering came fully under the jurisdiction of the Engineering Laboratory.

(2) In 1940, the last two major functions on the work stream, assembling (operation 8) and shipping (operation 9), were under the jurisdiction of two different divisions, the Manufacturing division and the so-called Traffic division. These divisions shared responsibility for the flow of work between them. The outflow from assembling was determined by the Manufacturing division and the inflow into shipping by the Traffic division.

By 1946, both the shipping and assembling functions had come under the jurisdiction of one division, Assembly. By giving one division full authority over both functions, responsibility for the flow of work between them was no longer divided.

(3) In 1940, the Manufacturing division and the Production Control division together controlled the flow of work along most of the work stream. Any piece of work, beginning as a paper, plan, or order near the head of the Engineering tributary (operation iiib) in the Manufacturing division, moved alternately under the jurisdiction first of the Manufacturing division and then of the Production Control division and so on alternately till it emerged as a finished part to become incorporated into the final product, at

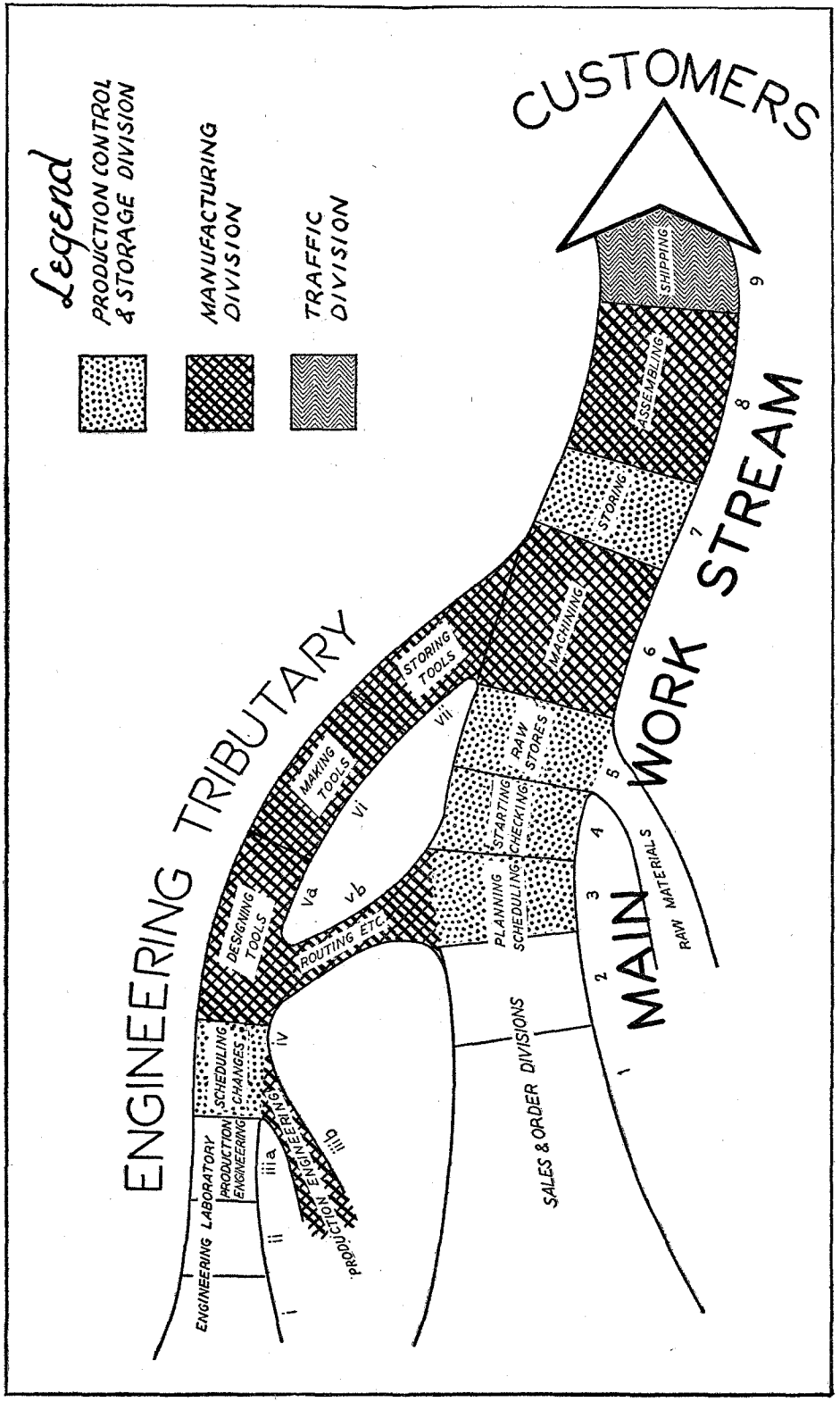


EXHIBIT III. THE WORK FLOW — 1940

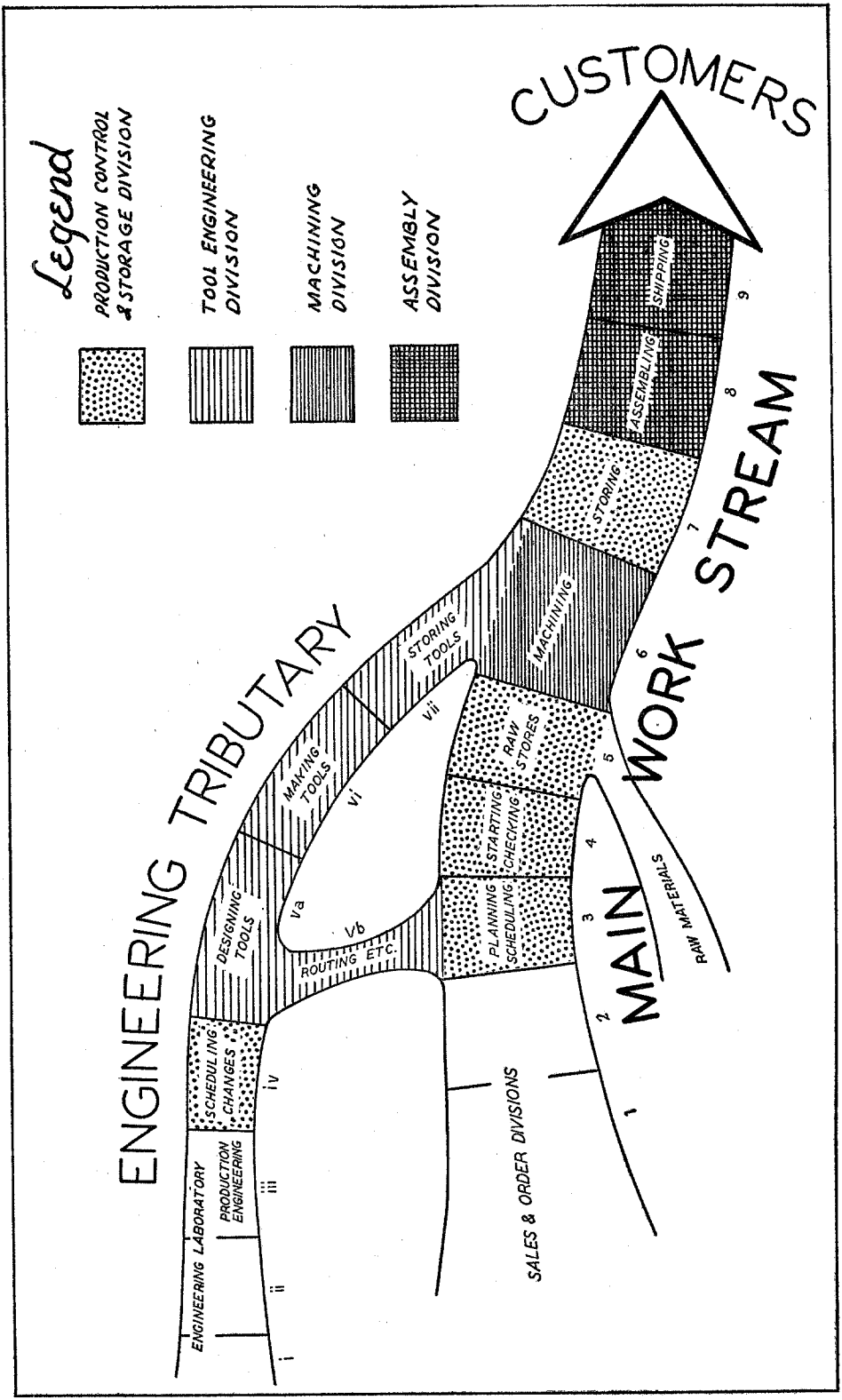


EXHIBIT IV. THE WORK FLOW — 1946

which point it was delivered to the Traffic division. This divided responsibility resulted in potential points of friction between the personnel of the Manufacturing division and the personnel of the Production Control division. Misunderstanding was accentuated because the work flow was erratic. When work-flow problems arose, persons from one of the divisions commonly blamed those in the other.

By 1946, responsibility over the flow of work along the work stream was no longer divided. The single Manufacturing division as such had ceased to exist. One of its 1940 functions, production engineering (operation iiib), was now joined with the similar function performed by the Engineering Laboratory, as already discussed. Authority over its other functions was split between three new divisions — one for each consecutive group of operations. Tool Engineering was now responsible for the design, manufacture, and storage of tools (operations va, vb, vi, vii); Machining for the making of parts (operation 6); and Assembly for the assembling and shipping of finished products (operations 8 and 9), the latter having been formerly under the jurisdiction of the Traffic division.

Interdivisional Control. These three new divisions, being independent, normally policed their own internal work flow according to production schedules set by top management and the Production Control division. But between divisions the flow became regulated by the Production Control division, which is now the only division controlling more than one continuous segment of the work stream. Sections of Production Control are intercalated between all other divisions along the work stream. All jobs, upon leaving one division and before entering the next, have to pass through one or more sections of the Production Control division. In the downstream work flow, therefore, these series of sections act as a system of dams regulating the outflow of jobs from one division to conform to the inflow requirements of the next division downstream. In some cases the flow must be speeded up, in other cases slowed down.

The extent to which these sections of the Production Control division have been consciously placed as interdivisional regulators of work flow is not clear. They seem to have assumed their position and the performance of their functions gradually through trial and error and as a common-sense adjustment to real problems — e.g., how to keep work freely flowing and how to eliminate "friction zones" that arise where divisions abut along the work stream. Our study suggested that friction inevitably resulted if the outflow from an upstream abutter did not conform to the inflow requirements of the downstream abutter.

We have seen that three methods were employed to minimize this friction. One was to merge abutting operations in one division, as done with assembling and shipping. The second was to restrict the authority of any one division to a consecutive group of operations along the work stream, Production Control excepted. The third was to use Production Control sections as buffers between the independent divisions; under the jurisdiction of the Production Control division these buffer sections regulated all interdivisional work flow according to a master plant-wide plan. All three methods repre-

sented adjustments to the work-flow situation.

It goes without saying that the writers do not imply that all cases of divided authority necessarily produce bad human relations. Many other factors, such as personality, factory organization, and so forth, are involved. The writers believe, however, that the method of analysis here presented — looking at the horizontal distribution of authority — may in other cases also help in clarifying the problem.

Level of Coordination

Although to the engineer the flow of work through assembly lines moves, or should move, from operator to operator along a straight line, from the standpoint of men and supervisors who make the work flow the picture is a different one. It is two-dimensional. Lateral communications between workers along the work stream are of course essential. But above each worker is also a vertical ladder, and communications up and down these ladders are equally necessary — in anything but an automatic factory — if the flow is to be continuous.

Every man in IBM's assembly line, for example, in addition to being related to others by his position in the line of work flow, is related to the men organizationally above or below him on a ladder made up of worker, keyman, foreman, department head, division head, plant manager, and general manager. (In 1947 keymen no longer existed, and department heads were rare.)

Both relationships must be "right," the vertical and the lateral, if the system is to work well. The typical effect of growth on factory structure is to increase the vertical distance between worker and management as well as the lateral distance between the first and last man on the flow line of work. Both kinds of expansion commonly create problems.

When problems of lateral extension become acute, it is said that the "control system" is faulty or has broken down. Keeping the work flow uninterrupted is the specific function of production control, and it is significant that long assembly lines in mass production factories invariably call for bigger and better groups devoted to that function. When the problems of vertical expansion become acute, it is often said that the supervisory system has become top-heavy or bureaucratic. More specifically, as companies grow in size and introduce progressive assembly lines, the loci for control of the work flow tend to move higher in the managerial hierarchy; responsibility is subtracted from those closest to the actual flow of work and vested more and more in those "higher up" and "farther away."

In order to understand what happened at IBM — with expansion to twice the number of workers and management's introduction of progressive assembly — we undertook to study two things: the actual level at which work flows through the factory from worker to worker and the actual level at which it is coordinated or controlled. Comparison of 1947 with 1940 shows the third major change we found in the reorganization of the work flow.

Our findings are shown graphically in EXHIBITS V and VI, which picture for 1940 and 1947, respectively, the position of persons in actual sequence along the main work stream, and also show everyone's position vertically according to levels of authority. The levels of authority are to be understood as actual

EXHIBIT V. TWO-DIMENSIONAL WORK STREAM — 1940

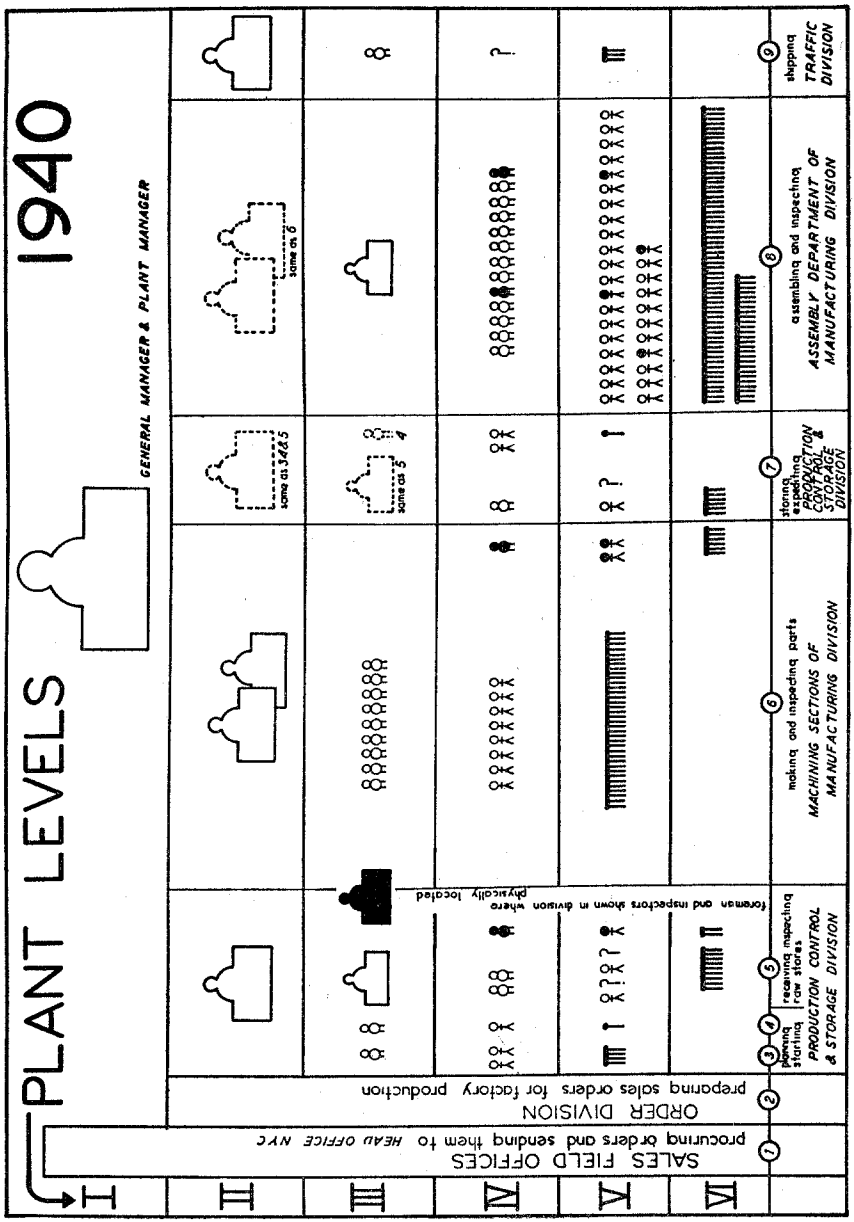
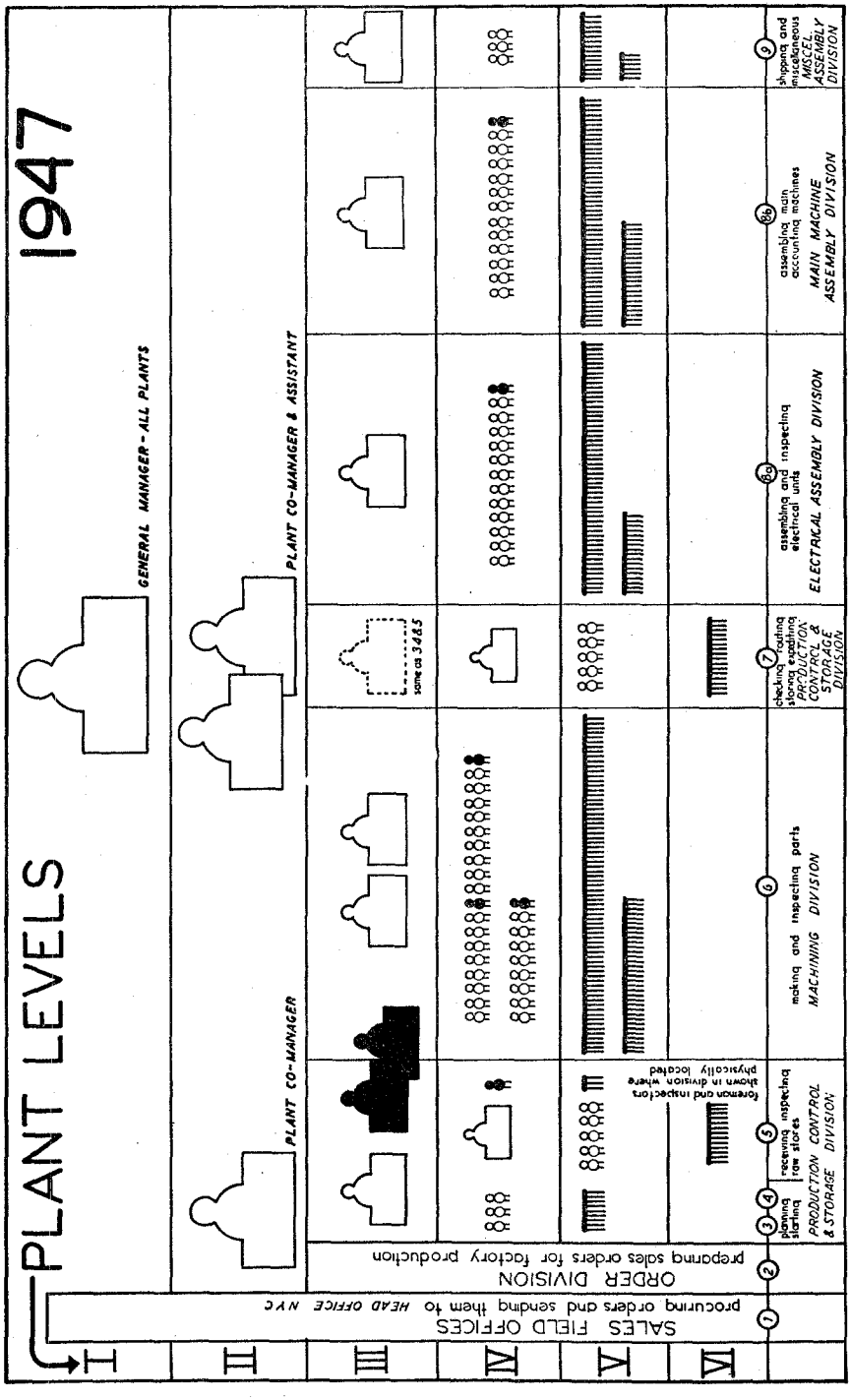


EXHIBIT VI. TWO-DIMENSIONAL WORK STREAM — 1947



NOTE: Production Control sections, separating Assembly divisions, have been omitted for the sake of simplicity.

supervisory and reporting levels, i.e., they show who supervises whom and who reports to whom for directions in the doing of his job.

For greater clarity certain sections have been eliminated from the chart, such as the night shift and all final assembly sections except those concerned with assembling the main machine. This leaves a total of 1,546 people in 1940 and 3,101 people in 1947. The 1947 picture, it should be noted, shows the effect of the Assembly division's being split up into further independent divisions since the reorganization described as of 1946.

Inspection supervisors are shown where they are physically located inside other divisions, illustrating the point that although administratively Inspection is an independent unit with its own head, inspection operations are actually spread out in the factory at various points along the work-flow line. In 1940 a somewhat similar situation existed regarding the expediters of the Production Control division assigned to Assembly, who policed the flow of materials in order to meet schedules; for the sake of simplicity these expediters are included with those engaged in storing finished parts (operation 7).

The symbols representing persons are arranged from left to right according to the sequence of operations. The actual flow of parts varies only slightly from that represented on the diagram. Likewise persons are arranged vertically in the scale of organizational authority. This gives us the two-dimensional picture. We are now ready to see who coordinated whom along the work flow, and why, in 1940 and 1947.

Cutting Down the Vertical Distance. At the very top of the organizational scale it is clear that in both years there was one man, the general manager, whose job it was to coordinate the whole factory work flow. But whereas in 1940 he was plant manager as well as general manager and personally participated in coordinating the work flow in the plant, in 1947 the job of plant management had been delegated to two plant co-managers and an assistant on level II. Thus the top coordination of the factory work flow was done in 1940 on level I and in 1947 on level II.

There is another point of interest. Since the "level I coordinator" in 1940 was general manager also, the factory was not his exclusive concern; conferences on company sales, finance, and other matters occupied a part of his time. But in 1947 we find that the work-flow coordinators (level II) were managers of the plant only and therefore that the factory alone with its related problems was practically the exclusive concern of these men.

The levels at which work flowed through the factory from worker to worker also shifted in the intervening years between 1940 and 1947. In 1940 it flowed about one-half on level V and one-half on level VI. Or, to put it another way, about half the workers (machine operators, assemblymen, and clerks) were on level V and about half on level VI. The reason is simple: certain divisions had more levels than others. For example, machining without a department head had five levels, whereas Assembly with a department head had six. By 1947 this extra level had in most cases been eliminated, largely by cutting out some department heads and doing away entirely with keymen, so that the work flowed through the factory from worker to worker more uniformly on level V.

The net effect of the changes described on efficiency of operation and on the system of human relations in the factory is of considerable importance and may be summarized as follows. The result of shifts from 1940 to 1947, in (1) the level along which the work flowed and (2) the level at which authority was placed to coordinate the whole work stream, has been *to bring the work level and the ultimate coordinating authority closer together.* In 1940 the coordinator was separated from the men in the work flow by four to five levels; in 1947 only three levels intervened. Moreover the 1940 coordinator gave only part of his time and attention to factory supervision; the 1947 coordinators devoted nearly the whole of their efforts to it.

The handling of daily work-flow problems can be made clearer by pointing out what happened when a conflict, hold-up, or other problem arose in 1940 at the lowest work level (VI), for example in assembly. The problem was passed upward to keymen (level V), who would pass it to a foreman (level IV), who often would pass it to a department head (level III), who not infrequently would pass it to the division head (level II). And the conflict was at times only resolved still higher up, on level I, by the general manager. By contrast, in 1947 problems originating at work level V were often solved on that level. If not, foremen on level IV usually solved them. The few that remained unsolved were handled by division heads on level III — practically never by executives on levels II and I.

It is not surprising that with fewer levels and with a better disposition of time on the part of both foremen and higher supervisors a solution to work-flow blockages was achieved. This achievement meant that responsibility had been thrust downward to the workers and their immediate supervisors. It meant by the same token a certain freeing of upper levels of management from day-to-day pressures. Whereas the job of controlling the daily work flow in 1940 took the time and attention of all five executives shown on levels I and II, in 1947 daily work-flow problems never rose to levels I and II and with less frequency to levels III and IV.

Conclusion

Certainly all factories are different from each other in countless tangible and intangible ways, but every factory has a work flow and human beings stationed along the work stream from the headwaters to the delta. We have found it useful to describe this work stream as two-dimensional. Persons are aligned horizontally along the banks of that stream in a sequence determined by the operations they perform. Inevitably, therefore, each individual is closely related to his upstream and downstream neighbors. In the same way, persons are related vertically to one another up and down a ladder of supervision in an order determined by who supervises whom and who reports to whom.

Along this two-dimensional work stream we have described three organizational changes which may have possible application to other companies faced with similar problems of organizational growth. It would appear to be desirable and practicable, for instance, to reduce what might be called the load of supervision carried by our larger factories. The word "load" is used advisedly, to suggest both a payroll burden for management and a psychologi-

cal burden for the average worker. By certain technical and administrative changes, that load was actually cut in half in the example studied.

A second organizational change was connected with "friction zones" between sections along the flow of work. There would appear to be two cures for this organizational difficulty: first, through one division's taking over the sections of the abutting division and so regulating the upstream or downstream troublemaker; second, by inserting a "buffer" section between the troublemakers.

The third change was connected with the level of the coordinating authority and the level of work flow. In the example given we indicated that the positions of department head and keyman were largely abolished with the result that the vertical distance separating worker from plant manager shrank from five to three levels. Necessarily, this reduction was only possible through delegating to foremen and workers responsibilities formerly assumed by department heads and keymen, a highly significant change in the factory's system of human relationships. Through this reduction in levels and other changes workers and foremen were brought "closer" to management. The net result was improved morale and productivity.

The connection between technology, work flow, and human relations is close, and certainly closer than one would guess from the little attention which many social scientists pay to it. Technology and engineering, based on the principles of physics, chemistry, and biology, determine manufacturing processes and certain sequences within those processes. The work flow must conform to these over-all technical limitations, but within that framework a very considerable choice exists between the types of human adjustment possible. To improve the choices for this adjustment, much experimentation needs yet to be done.

To turn once more to our study by way of illustration, the company experimented with two ways of organizing the work flow in assembly operations: one, the job lot and circuitous work-flow system which was being practiced in 1940; the other, the progressive assembly system calling for a new layout and improved scheduling which we found functioning in 1947. A different supervisory system was associated with each of these systems. Conceiving the work streams as two-dimensional, then, we can see that each produced a different kind and degree of human cooperation which in turn resulted in differences in employee morale.

Not content with its success in eliminating two "levels" from the supervisory ladder, this particular company hopes to eliminate more. The management is experimenting further to reduce what we have called the supervisory load and to approach closer to the goal of a frictionless work flow. If organizational pioneering of this kind continues, we may some day reach that point of human adjustment and satisfaction which is actually possible within the technological limitations of our modern factory system.