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Japan Report

(FOUO 26/81)

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CONTENTS

MILITARY

MILITARY BUILDUP BUDGET CURTAILMENT EXAMINED

Tokyo ASAHI JANARU in Japanese 30 Jan 81 pp 10-17

[Article by Hideo Ohtake, Assistant Professor of Law, Tohoku University: "Inside Story of the Making of a Military Build-up Plan"]

[Text] (Foreword by editorial staff) In spite of the widely expressed contention that without an increase of at least 9.7 percent over the preceding year Japan-United States relations would deteriorate, next fiscal year's defense budget increase has been held down to 7.61 percent. This shortfall came about in spite of loud and broad support for a stronger defense force accompanying anti-USSR propaganda and a trend toward conservatism.

What happened during the process of putting the defense budget together?

What actions were taken by the 'hawk' factions in the Liberal Democratic Party (LDP), 'defense dietmen' [Self Defense Forces and the Defense Agency Officials turned dietmen], and former Director General of the defense agency, to defend the 9.7 percent increase? When Prime Minister Suzuki suddenly announced a political decision to put the defense budget under wraps by saying that "If the subject is forced at this point, we are going to lose all." Why didn't the various factions within the party react and resist vigorously?

The ensuing article investigates the political structure and power plays within the LDP which had been aiming at broad increases in the defense budget and the general public's opinion with regard to defense spending.

[Text of Article] The decision as expressed in the government's proposed Japan Fiscal Year [JFY] 1981 budget, to increase the defense portion at a 7.61 percent rate has given rise to two lines of reaction from both those who desired a defense budget increase and those who were against it. For example, the mass communication media which is normally critical of defense spending increases, is of two opinions: On the one hand, there are editorials which attach much significance to the fact that in a total budget which has been held down to an increase of 4.3 percent, defense not only has a proportionately much larger increase but, though small, the increase is more than that apportioned to socal welfare measures (7.6 percent); other editorials question the wisdom of cutting by more than 2 percent, the minimum increase of 9.7 percent pressed on Japan by the United States, particularly at a time when it is showing a turning-to-the-right trend. The situation is the same in opposite camp, the political power camp, which in a self-laudatory way, claims that even this period of economic crisis, the fact that defense expenditures have been alloted a higher rate of increase than that for the total budget should indelibly impress all concerned that Japan is a full member of the western bloc. But there are those who apologetically say that because there is still inadequate understanding by the general public, surrendering to the Finance Ministry's pressure was unavoidable.

Needless to say, these varied comments reflect differing policy positions and political postures; it is necessary to note, however, that the budget is considered in the light of differeing levels of priorities. Basically, during the 70's there was an increasing trend to the right and during the past two or three years, a growing "second cold war" atmosphere. With this as a backdrop, the increase of 7.61 percent --emphasis placed on frontline equipment--reflects a breakthrough in defense spending which has been in a stalled state for the past 10 years. In contrast to that viewpoint, in spite of the landslide victory in the double elections which enhanced the hawks' position and the bold pressure applied by the United States which lead to an official agreement that there would be an increase of 9.7 percent (11.9 percent with the inclusion of personnel expenditure), counterattack from public opinion and Finance Ministry forced the paring of the increase to the 7 percent level during the actual compilation of the budget.

This article is aimed at investigating the elements which influenced the making of the budget, particularly during the September-December period of last year. Although it will be weighted to the developments during that last period, the political situation which lead to increase consciousness will be viewed to prevent losing sight of the big picture before making detailed analyses of events and situations and describe the making of the final budget in terms of its political significance.

By the summer of 1980 several reasons favoring a broad based increase in defense spending had become clearly defined and made ready for introduction to the political arena. With a basic demand that the defense budget be considered as a separate entity, supporters seemed to be in a position to overwhelm the Finance Ministry's cry for a compressed budget to cope with the economic crisis. The increase in Soviet naval power in the Far East during the 70's and the invasion of Afghanistan in 1979 gave the right wingers in the LDP excellent justification for their demand.

The easing of U.S.-China, Japan-China relations, the SALT I representing progress in detente, and the slowing of economic growth rate during the mid-70's had been reasons for the government and the LDP to voluntarily apply a degree of restraint against increase in military spending. The Fourth Defense Plan drawn up by the then Director General of Defense Agency Nakasone was broadly whittled down and further reduced in its implementation stage. This left such a large lag in planned defense measures that the long range defense plan (Fifth Defense Plan) which was due during the tenure of Sakata as the Director General of the defense agency, had to be scrapped in its formative stage. This not only led to giving up on plans to attain defense plans 1st through 4th at a faster pace, but also increased the rear service support and equipment structure with commensurate increase in personnel expenditures, and spending on research and development lowered. With worsened economic situation under the lowe growth period during the tenure of Prime Minister Miki and Defense

Agency Director General Sakata, the basic concept of defense forces and its defense guideline, defense spending was limited by the cabinet to no more than 1 percent of GNP which had the effect of being highly supportive of detente.

At this point, it is important to note that two major changes came into being. The first was that the 'Sakata line' which gave up on rapid increases in defense strength, created a situation under which dependence on United States military was increased, and manifested itself in the strategic plans involving the United States. We do not have the space here but it is an undeniable fact that this will intensify and affect more facets during the 80's.

The other point is that then Director General Sakata launched a vigorous public relations campaign to promote "understanding" of the Self Defense Forces. Curtailment of defense spending was a very convenient tool to soften the impact on public opinion (footnote 1). The Fukuda cabinet gave its support to the public relations campaign and boldly took up defense problems, a turn about from the taboo that had been put on defense discussions, and vigorously worked on the PR project. Subjects pertaining to strategic planning and constitutional revision were brought up successively, forcing the opposition political parties to make a 180 degree turn to the defense. Without these two changes, the joint military strategic plan with the United States refered to above, never could have been effected.

These measures taken in the 70's set the stage--objectively, if not subjectively--for the move to increase defense forces during the 80's.

In this atmosphere, the Afghanistan problem presented the 'right wing' of the LDP with a golden opportunity to accelerate its move to gain power. Of even more significance, however, was that during the past 2 years, pressure applied by the United States on Japan was being radically increased; using rising economic friction between Japan and the United States as a backdrop, congressional criticism of Japan's "security free ride" intensified. This lead to gaining the support of the group which viewed the Soviet threat lightly but which felt a need for eased pressure from the United States. In other words, the concept of keeping a lid on Japan's defense powers for the purpose of promoting cooperation of the United States had to be replaced by one which required increased defense force to achieve the same purpose. The LDP was not alone in seeing the need for this change; the viewpoint became widely accepted in the Foreign Ministry, the Ministry for International Trade and Industry [MITI], and in private financial and economic circles which put much weight on relations with the United States for political and economic reasons. This was how a new consensus was formed among Japan's elite.

In this flow of events, an estimated increase of 9.7 percent was decided. This figure gave the footing for the Defense Agency to request a 12 percent increase including the increase in personnel expenses and also to request that there be provisions for further increases should there be changes in the situation. To the latter request, Finance Minister Watanabe replied: "Let's discuss that case by case as the situation changes" which was taken as a 'response with understanding [positive].'

Defense Agency Accepts 9.7 Percent Increase Ceiling

When the political manipulations--which took place during the whole year [1980]--is viewed on the assumption that the entire process was aimed at an increased ceiling of 7.61 percent, a certain rationale can be discerned; confrontations and arguments during the process of putting the budget together since last fall, all concerned themselves with this upper limit. However, there is room to suspect that the defense agency and the 'defense dietmen' were not fully appreciative of the rigidity of this ceiling decision and because of that, the defense agency was guilty of making two tactical errors in handling the ceiling problem.

The first error lay in the fact that during the summer months, it had failed to obtain clarification on whether the increase in the rate of expenses pertaining to personnel matters was included in the 9.7 percent rate of increase. It is believed that the government's leadership purposely left this point vague to assure itself room for later maneuverability. The Defense Agency, therefore, entered into the final stage of formulating budget without clarification. As will be described later, when the budget enters into the final stage of compilation, conflicts and coordination with other elements come to the surface, the defense oriented Diet members have dispersed and support of the foreign ministry becomes undependable. Under such circumstances, it is only natural that the consensus which had existed earlier breaks down. Therefore, the decision-making time for budgetary requests is the only time to obtain favorable decisions on such as personnel cost matters. By letting this opportunity slip through its fingers, the defense agency forfeited the chance to obtain appropriations to cover increased expenses pertaining to personnel matters.

The second error was the Defense Agency's failure to include supplementary appropriations in the budgetary request to cover contingencies under which the increase of 9.7 percent was found to be inadequate. The absence of a mechanism to ask for supplementary appropriations was taken as an admission that the 9.7 percent increase was in itself an unachievable figure. The fact that the defense agency accepted the 9.7 percent increase without a struggle was a source of disappointment and dissatisfaction to defense oriented Diet and Foreign Ministry members. It is believed that this passivity on the part of the defense agency resulted from pressures applied by agents dispatched to the budget people of the agency by the Finance Ministry and to lingering legacy of defensiveness which kept it from riding the crest of the new wave. In any event, by limiting itself to a ceiling of 9.7 percent increase, it was inevitable that it had to retreat from it in the final stages.

It can be said then, that the 9.7 percent ceiling was the cause for the resultant increase in the 7 to 8 percent level. What was the source of the power and how was it manipulated to lower this 9.7 percent figure during the final stage of budget making during the September-December period? How did the defense agency and the national defense committee cope with this force? What were the political implications? It is our intention to investigate these political power plays and through it, study the causes for defense spending being held down. We wish to present these facts to determine whether defense spending can be controlled by the people itself. We acknowledge that the Ohira-Charter agreement had a great impact on the situation at the time, the passing of former Prime Minister Ohira and the defeat in the November elections of Carter, it lost much of its clout. Because of space limitations, we will omit a detailed discussion of that aspect.

Of the political entities which played major roles in the formation of the budget, we intend to focus on the principal elements with the LDP in the investigative report which follows.

Within the party in power, the ones who were most actively engaged in trying to increase defense appropriations were policy groups made up of those who are commonly called "defense dietmen." These men are members of the national defense committee or security research association under the party's policy board. Using those organizations as their point of departure, they worked hard to influence the party leadership and the finance ministry. These organizations met jointly with the special committee on military bases and frequently assembled formal and secondary conferences and had the chief or deputy chief of the defense agency make status reports. Resolutions were drawn up at such meetings and they were submitted to the prime minister, the chief cabinet secretary, the party's three directors, and the finance minister. Sometimes its representatives would summon the accountants of the Finance Ministry's bureau of accounts to brief them on the need for increasing defense expenditures in support of the defense agency.

For example, on 24 December, a day in the highly critical period in the final stages of budget making, it is reported that the office of the chief cabinet secretary was taken over by about 25 members of the "defense dietmen" for about an hour and that the atmosphere inside was likened to a "lynch Chief Cabinet Secretary Miyazawa' (footnote 2). However, such pressure tactics at decision time for appropriations occur in the same way in other ministries and agencies and cannot be described as a departure from the established pattern.

In the final analysis, the "defense dietmen" whose actions could be described as outgoing or flamboyant, had no power base which could affect budgetary decision making nor could they find any influential supporters to act for them behind the scenes. In the first place, there were no "defense dietmen" who held influential political positions within the party and they lacked strong leadership. In the second place, neither the Defense Agency nor the "defense dietmen" had any support from industrial or organized grass-roots constituency groups. In the third place, they failed to garner any backup from influential cliques or factions.

The leadership of theNational Defense Related Committee included such personages as Minoro Genda (National Defense Committee chairman), Motoharu Arima (vice chairman), Asao Mihara (Security Research Committee chairman), Noboru Minowa (deputy chairman). These were the men who were in the forefront of those who spoke in behalf of the budget. One glance at the roster should be enough to show the lack of any realistically influential Dietman--with the exception of Mihara--or any with a central stature in the party. The one person who was the most active and single minded in his efforts, Minoru Genda, was apt to be an isolated figure within the party because of his militaristic personality. He is completely inappropriate as a leader of the national defense group. (footnote 3)

There were rumors to the effect that the 'defense dietmen' and the party's leadership were not in complete harmony. Credence was lent to them by the fact that when the party leadership decided to put the lid on at the 7 percent level, it encountered much difficulty in getting the 'defense dietmen' to "strike their colors." Even after the Director General of the Defense Agency and the head of its administrative office had come to terms in the final stages, the 'defense dietmen' refused to budge from their 9.7 percent position. The man who was assigned by the party leadership to resolve this situation was a 'defense dietman' himself, former Director General of Defense Agency Mihara. By acting as the only conduit from the party leadership, he was able to talk the 'defense dietmen' into accepting a truce but the day to day relationship between the defense groups and the leadership was anything but smooth.

Beside the situation described above, the men who have been described as 'defense dietmen', had work to do on other budgetary appropriations with the exception of Genda. Most of the 'defense dietmen' had as the nucleus of their constituencies, members of the Families of Japan's War Dead Association. The finance ministry had issued warnings that if defense spending was increased on a broad scale, survivor benefits of those veterans could be adversely affected. Thus the 'defense dietmen' were placed under countering pressures. (footnote 4)

Within the party there were several members of the Diet who were former director generals of the Defense Agency such as Shin Kanemaru, Michio Sakata, and Yoshio Hosota (Mihara mentioned earlier could also be included). Their views were favorable to the Defense Agency's. Although these persons are key figures in the party structure, they had to give prior concern to budgetary appropriations of other ministries and agencies and for that reason could not make adequate efforts in behalf of the work on the defense budget. Kanemaru, for instance, was primarily of the "highways clan" and in that capacity had to concern himself mainly with construction appropriations; Sakata represented the cultural and education family and the elderly and therefore had to become involved in education ministry's appropriations. The foreign ministry and foreign relations groups in the LDP who had vigorously aided the Defense Agency in the past, had to turn their attention to increasing the appropriations for foreign aid rendering almost insignificant assistance to the problem of defense appropriations. Because decision making in the budget making process is cyclical in nature with seasonal concentration of effort coming to a climax in December, the 'defense dietmen' who formed the pressure group in the party, found themselves fighting its battle in isolation (the trend of the consensus in the party to the right stopped at the point of being the silent majority and failed to exert any practical influence.)

The minimal influence that the 'defense dietmen' could garner can be traced to the failure of those Diet members to get the backing of influential industrial groups and of any grass-roots constituency elements to organize and actively support them. They did not buld a footing through those who represented arms industries within the party.

Defense Budget Making With No Link to Election Votes and Political Contributions.

'Defense dietmen' based their campaign solely on 'philosophy' (advocating the need to have defense forces')--generally labeled as a 'confidence game.' Their approach to the Finance Ministry was to argue for increasing the total defense appropriation without spelling out the requirements in detail. According to persons concerned, those who sought increases in appropriations for road construction or expansion of primary and secondary school facilities requested favorable consideration be given to certain undertakings in given local areas; the 'defense dietmen' made no such presentations for their requests to the Finance Ministry. If this is true, it becomes evident that in the negotiations phase with the Finance Ministry, the LDP's political interest structure was not concerning itself with the budget making process.

Let us investigate this problem from two viewpoints. In the first place, Japan's arms industry complex is small; it has not developed to the point where, in any given locality, it has a life or death grip on stability of employment or business trend. In the United States where the military-industrial complex is a gigantic establishment, the labor unions oriented arms industries form the vanguard in lobbying for increasing (or against reducing) defense spending. Members of Congress whose constituencies contain such interests represent those interests and play an important role in influencing the various congressional committees concerned with defense matters. The hawkish arguments being put forth very recently by members of the Japan Democratic Socialist Party [DSP] may be a germination of such a pattern but no indications can be discerned in the LDP that any of its Diet representatives is reacting to pressure by such constituents.

In the second place, as was seen in the Lockheed incident, a distasteful connection has been created between munitions manufacturers and businesses and the leadership of the LDP. This type of political rot has been subjected to close scrutiny of industries which are recipients of contracts within the confines of the budget. In other words, there seems to be no indication that the munitions industries have unified to the point of being able to push up the total defense budget ceiling. Insofar as the next fiscal year is concerned, there is no evidence that the arms industry made any direct overtures to the finance ministry or the party of the government. (Because of the nature of the matter, we have to qualify that statement with 'as far as the author can ascertain.') At least, defense costs have not been significantly increased due to pressure from the munitions industry.

From the above, it seems evident that the request for increase in defense appropriation stems only from an overall trend to the right in LDP's ideology and that there has been no close ties to vote getting and political fund raising which is the LDP's source of power--its 'money-powered structure.' To the contrary, we believe that by placing emphasis on vote getting, the party is striving to balance party interest with service to the constituency and deemphasizing the importance of political ideology. The very structure of money politics itself is screening off the possibility of the recent appearance of cold-war sentiment from filtering down to the mass level and engulfing it.

Of course, if, as is occasionally pointed out with reference to U.S. politics, right wing ideology becomes enmeshed with special interests politics through a military-industrial complex, it is probable that that ideology and those politics will be nurtured and will show growth. At the present time, however, we can discern no evidence of such a development. The insignificant influence that the 'defense dietmen' can muster attests that fact.

The leaders of the Fukuda faction, particularly Takeo Fukuda and Shintaro Abe who were heavily imbued with hawkish philosophies and who held influential positions in the power structure within the party, have the potential of turning the situation around.

Fukuda as the leader of a key faction, is an element essential to the stability of the Suzuki government; Abe is one of the LDP's troika--the comptroller of political affairs, a position which controls budget making. (footnote 5) Moreover, since the Afghanistan incident, the Fukuda faction began to show considerable sympathetic understanding of Minoru Genda's defense philosophy. (Footnote 6)

It is a fact that on 23 December, a climactic date for final budget decision making, Diet members of this Fukuda faction together with the Nakagawa group, mobbed the joint committee on national defense matters and created quite a scene. This was instigated by the fear that if no overt steps were taken Prime Minister Suzuki's low key approach would be written into the budget as was. It was carried out as a final demonstration of protest. However, the assumption of an overly tough attitude at this point would have upset the budget making schedule and would drive the Suzuki cabinet which was administratively responsible for making budgetary decisions, into an embarrassing spot. It is said that with this in mind, the government approached the Director General of the Defense Agency through many channels and obtained concessions from him.

Thus, the activities of the Fukuda group went beyond the bounds of policy confrontation and could easily have developed into an intraparty power struggle. For this group to push on, it had to be prepared for a change in the government and, under certain circumstances, cause a split in the party. Conversely, from the mainliners standpoint, it was essential that the group for increased defense spending which was conducting its campaign in the manner described above, be sealed off by all available means. It is reported that the reason that former Director General of Defense Agency Kanemaru of the Tanaka faction who had been exceedingly vociferous in supporting increased spending in the fall became silent in December is traceable to these political contingencies. The same consideration lead Executive Council Chairman Susumu Nikaido who had, together with Policy Affairs Research Council Chairman Abe proclaimed that if defense spending had to exceed welfare's, so be it, to become discreetly quiet. So, after 10 December when Prime Minister Suzuki made his position clear, a large crimp was put in the demand for increased defense spending.

There was no other channel through which matters concerning defense budget decisions could be voiced except through Director General of Science and Technology Agency Ichiro Nakagawa who could make comments from his seat in the cabinet since his is in an uncommitted, carefree position.

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As demonstrated by the typical response to the Fukuda faction's activities, budgetary decision making is a very important administrative responsibility for the cabinet and the fact that the time schedule has to be strictly adhered to, maintenance of the status quo gained momentum. So at the final accounting, Director General of Defense Agency Omura and Deputy Chief for Administration Hara had to play the role of conciliators with 'defense dietmen'. In this instance, the balance though delicate, among the factions supporting the Suzuki cabinet favored maintaining the status quo.

In addition to the above described factors, it must be pointed out that the budget making process inherently contains a 'gradualism' quality which leans to conservatism and to keeping things as they were. This 'conservatism' tends to restrain rapid increase in spending but simultaneously offers strong resistence to spending cuts. That the 'welfare dietmen' who were in a more vulnerable position than even the defense people (footnote 7) were able to assure themselves a growth rate equal to defense's can be attributed to this quality.

Budgets of most countries are, as a general rule, influenced by this tendency for 'gradualism' or 'incrementalism.' In this particular one in which each ministry and agency tried to draw appropriations from the others, it had the effect of dampening a broad scaled increase in the defense budget. In other words, if the government leadership and the Finance Ministry made concessions to defense, there was a fear that the other committees of the LDP would interpret it as a breakthrough and make demands of their own which could not be repressed. As a point in fact, when approval was given in August to handle defense's budgetary estimates as a special item, "other committees within the party, feeling that the 'defense dietmen' had just about succeeded in getting the increase, showed signs of forming a 'me, too' movement in unison." Discerning this, the party leadership lamented that "special handling of the defense budget has set all other committees on fire." (footnote 8) Because of this bitter experience, matters pertaining to the defense budget could not be cut out and handled separately after the autumn of the year. Moreover, since the Finance Ministry assumed a tough attitude in keeping the total budget under control, defense costs and other appropriation items were held to a 'zero sum' relation. For that reason, not only did it fail to gain the unfettered assistance of the defense family and the support of other Dietmen who might have formed a cheering section but instead, met opposition from the welfare group which charged that defense should be held down. As you already know, Minister of Health and Welfare Sonoda lead this group but the social affairs committee of the LDP worked toward curtailing any increase in defense costs. In this atmosphere a "balance" philosophy began to be heard and it became the instrument which was the determinant in budget decisions.

However, it would be incorrect to place the blame only on the lack of influence on the part of "defense dietmen" and on nebulous "gradualism" or "incrementalism." We must not forget that within the LDP there were elements which were intent on repressing defense spending and exercised their political clout to achieve it.

It is safe to assume that since the Ohira government these elements which consistently adhered to that line, existed in the party. Prime Minister Suzuki who succeeded Ohira, vigorously upheld that thinking. Although until December, Suzuki avoided making the increased defense budget problem from publicly becoming an issue for prime ministerial decision making, he assumed a clearcut leadership role in the final stages of budget making in December. The decisive action which was to influence the final outcome came immediately prior to the visit of Defense Secretary Brown of the United States on 10 December when he summoned top administrative officers of the Foreign Ministry and Defense Agency. Referring to the strongly presented requests by the leadership of those administrative offices for the acceptance of a 9.7 percent increase, the prime minister said: "The line of thinking (taken by those offices) that Japan-United States relations would be impaired if the 9.7 percent increase was not achieved is erroneous." With those strong words, he made it clear that the requested appropriation would not be approved. During the meeting meeting with Secretary Brown, he stated that considerations had to be given to welfare and education and to a balance in expenditures and finances to shift the pressure. Then, on the 15th while briefing the conference of leaders of the government party on his talks with Secretary Brown, it is reported that he made the following observation: "Our country's defense consciousness has finally been aroused. Unfortunately, it comes at a time when we are confronted with economic problems entailing the need for tax increases. If the defense issue is pushed too hard now, there is a danger that it [defense consciousness] will fade away. Under these circumstances, the wisdom of giving prominence to defense spending must be questioned."

This judgment clearly indicated that the policy would be to hold the increase to below 9.7 percent. After that the three directorates of the party each stated that "the lowering of the 9.7 percent cannot be avoided," and the promise to the United States had to be withdrawn. After 20 [December] the defense agency shifted to improvement of frontline equipment to keep within the reduced increase.

Under such circumstances, the pro-defense members' subsequent activities in behalf of 'increase to 9.7 percent' was met by the Defense Agency as a mixed blessing.

In the meantime, Prime Minister Suzuki advanced to argument in defense of his disavowal of the 9.7 percent increase. One was to the effect that "to push up only defense appropriation could arouse the people's ire which could develop into obstacles to realizing adequate defense budgets subsequent to JFY 1982." This is similar to the line used in his briefing of Secretary Brown and to the statement to government's party leaders' conference. The argument, with an eye to bringing in higher consumer taxes, was along the following line: "Curtailing social welfare programs which directly affect the people, while increasing defense spending on a broad range could arouse violent criticism against increased taxes and could put economic revival in jeopardy." In essence, the argument was for the maintenance of balance between welfare and defense.

Behind these arguments is the conviction that the "leaning to the right" of public opinion isn't strong enough to accept a big rise in defense spending. This conviction stems from confidence as a politician in party politics. We cannot overlook the fact that economic revival is the primary objective of the Suzuki cabinet. In other words, the Finance Ministry's philosophy had succeeded in infiltrating the Defense Agency, the Foreign Ministry, and the "defense dietmen." The argument for carrying out measures to rejuvenate economics even at the cost of some public opposition was given the higher priority; increasing defense strength was judged not to be quite as important.

In any event, public opinion was the determining factor in the government leadership's decision to clamp a lid on defense spending. Furthermore, there is very little doubt that the majority of Diet representatives of the LDP was in agreement with this estimate of public opinion. Regardless of a Diet member's views on international affairs or his position on nationalism, he felt that the people would object strenuously to any broad scaled increase in defense spending accompanied by cuts in funding public undertakings or welfare while taxes were increased. This assumption was common throughout the LDP. LDP members have the reputation of keeping in close touch with the grassroots in order to serve their respective constituencies better. This practice has earned them the common saying that they are the "home on Friday, back on Tuesday" bunch but it has made them very sensitive to public opinion, particularly as it pertains to the elections. They attribute the in-party's "defeat" in 1979 to Prime Minister Ohira's tax increase program and have guarded against having that issued get tied into increase in defense spending. To cope with reactions of public opinion, it has been pursuing a very pragmatic policy. It has been able to maintain its position as the party in power for four and a half decades by its flexibility and by keeping itself free of any ideological label. In this instance too, as seen in his statement referred to earlier, the prime minister exercised considerable discretion when he said in effect, "forcing the issue here might result in retrogressing," in spite of the careful buildup of sympathy for defense over the years since Director General Sakata's time.

Summing up the above points, it is evident that paralleling the Finance Ministry's budgetary restrictions, public opinion with the LDP as intermediary, played an important role in keeping defense spending increases under control.

However, we believe that the leadership of the LDP estimated that there would be no criticism of defense cost increases if they did not relate to a tax increase or to cuts in welfare spending. An upturn in the economy could present a turning point in the fortunes of the defense budget. It is of great concern to the LDP that its estimate of public opinion agrees with actual public consensus.

Footnotes

1. It is almost impossible to estimate the extent of contribution made by the various activities in the "turn to the right" movement since Sakata's incumbency. Within the LDP itself, there is a strong inclination to credit autious discretion as the guiding force in achieving results. Exemplifying this was Prime Minister Suzuki's statement to the effect that since the efforts had brought us this far, let us not lose the source and the momentum at this point by forcing a broad scaled increase in defense spending. This attitude was given clear approval within the party. It is notable in this regard, that Sakata who had become a key figure among the "defense dietmen", sounded a warning for discreet action as early as the summer of 1980. (MAINICHI SHUMBUN 30 Aug 80)

2. NIHON KEIZAI SHIMBUN 25 Dec 80

3. Refer to my paper "The Defense Issue in the Liberal Democratic Party," a supplement to Law Studies Seminar publication "The Constitution and Defense" (recent pbulication) with regard to Genda's personal history and philosophy.

4. Generally speaking, bonus related lobbies are among the best result getters of all organizations that support the LDP; probably for that reason they have been assured of getting the entire amount requested included in the budgetary draft.

5. With regard to the interplay between overt lobbying among party policy groups and undercover activities involving factional leaders pertaining to budgetary decisions, an interesting behind the scenes article appeared in the ASAHI SHIMBUN 31 Dec 80. It pertains to the establishment of an annual postal fund for individuals, describing in detail how the Ministry of Posts and Communications oriented Diet representatives and Kakuei Tanaka/Susumu Nikaido (Chairman of the LDP Executive Council) combined to overcome resistance from the Finance Ministry. It is also alleged that actions were taken involving subsidization of school text books by the education clan of the Fukuda faction (ASAHI 25 Dec 80) There was a potential for similar battle lines being formed between the pro-defense members and the Fukuda faction.

6. With Mutsuki Kato and Ichiro Nakanisi as key figures, the Fukuda faction's research group took up the defense issue and with Takeo Fukuda as supervisory editor, published "Japan From Now On; Defending Our Country In Violently Changing Times" (Asahiya, publisher) in October 1980.

7. With regard to the welfare budget and the "welfare dietmen" of the LDP, a publication by Tetsu Ashizaki "Tales of Welfare Ministry's Cruelty" (Yale Publications, 1980) is a reference item.

8. CHUNICHI SHUMBUN 12 Aug 80.

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SCIENCE AND TECHNOLOGY

JAPAN'S SCIENCE, TECHNOLOGY POLICIES REVIEWED

Diet S & T Committee Chairman

Tokyo NIKKAN KOGYO SHIMBUN in Japanese 19 Dec 80 p 1

[Interview with Hiromi Nakamura, Chairman of the Diet S and T Committee--place and date not given]

[Text] [Reporter] We often hear the phrase "building the country on the basis of technology." Where should the emphasis be placed in carrying out Japan's future science and technology policy?

[Nakamura] We live in a small country, poor in physical resources such as energy and raw materials. We face the 21st century under these restrictions. Promotion of science and technology is essential to a stable economy and a better life for the nation. Where should the emphasis be placed in a policy for promotion of science and technology? As indicated by Director General Nakagawa of the Science and Technology Agency, there are four main needs. The first is to secure funding for research and development. Such funds in 1978 constituted 2.15 percent of the national income. The plan is to extend this to 2.5 percent soon and to 3 percent over the long term. The amount borne by the government in this will be expanded from the present 28 percent to 50 percent. The second need is joint promotion and improvement through government, education, and private business. The government research facilities, universities, and various private research facilities should be organically related. Third is greater development of independent technology. Previous dependence on imported technology must be overcome by promoting original technological development. Fourth is promotion of international cooperation. It is necessary to actively promote cooperation with the developing countries as well as with the advanced countries.

These four measures will be given priority and in the immediate future, science and technology related to energy, especially atomic energy, and raw materials will be actively developed. In addition it will be important to push ahead with development of space, the ocean, the life sciences, and disaster prevention technology.

[Question] In rebuilding public finances, the Ministry of Finance keeps a tight drawstring on the money bags. What is the best way to squeeze out the necessary money for research and development?

Also, I would like to know what you think of issuing national science and technology bonds as suggested by former Keidanren president Tsuchimitsu.

[Answer] We were fortunate to have science and technology included as a top priority in the budget structure in spite of difficult financial conditions. This is proof that building the country on the basis of technology has become our goal. The Scientific and Technical Council says that research and development expenses should be increased to 3 percent of the national income. We must increase them at least that much.

In order to do this, whether we use Mr Tsuchimitsu's suggestion of national science and technology bonds or not, some special revenue sources will have to be developed. The Tsuchimitsu plan will have to be studied carefully but since we are presently trying to reduce the amount of public bonds, the timing is bad for this. I would like to consider this as a special revenue source after a certain interval.

[Question] In technological development, the relationship between universities, government and public research institutions, and private industry often becomes a matter of controversy. What do you think is the best system for carrying out such research.

[Answer] I think it is best to have a division of roles--the university performing basic research, the government institutions doing applied research, and private industry working on industrialization and commercialization. At present, the private sector is shouldering at least 70 percent of the burden so I think it is necessary to increase the government's share. In addition, an organic relation is necessary between government, education, and private business. The Science and Technology Agency is planning to establish the "Original Science and Technology Promotion System" next year. In this unique system, the best brains will be gathered from the universities, special public corporations, and the private sector and under a leader they will develop certain advanced technologies. For a start, four subjects have been chosen for development including ultra-fine particulates and fine polymers. We definitely want to institute this fluid system of changing researchers.

[Question] Government and public research facilities are accused of being less efficient than private institutions. There are even those who advocate a system of contracting research out to private industry. What do you think about this? And what is the best way to raise efficiency?

[Answer] In view of the national character, I don't think that a research contract system would sit well with the Japanese people. "Piecework payment" also seems strange but I would like to consider it in the light of the contract system used by other countries. The significance of building the Tsukuba garden city for research lay in this area but I would like to watch its development further to see if it works well or not. My true feeling is that I'm a little doubtful that we can get results by imitating foreign methods.

However, it is necessary to eliminate redundancy in mutual research efforts and I would like to see cooperation and exchange of information.

[Question] Training of human resources is necessary for development of independent technology. Some say that with our present uniform education we cannot develop creativity. How do you feel about this?

[Answer] Training of human resources is not only important for science and technology but it is urgent to train and secure superior scientists and engineers. It is often said that there is a shortage of scientists and engineers but as of April 1979 there were 280,000 scientists and engineers in the country. That is 24 researchers for every 10,000 people. This is third in the world behind 39 per 10,000 in the Soviet Union and 27 per 10,000 in the United States. In view of this, we cannot state flatly that there is a shortage.

Furthermore, in 1979 there were 150,000 students who graduated from colleges in scientific and technical subjects. However, quality is more of an issue than quantity. For example, the study of ultimate materials and the life sciences is urgently needed and a shortage of researchers in this area will become an issue. It is claimed that the Japanese are low in creativity. We need to think about reforming the present "examination hell" type of examination system and create an education system that will train people to be more creative. In this sense, holding the International Science and Technology Exposition in 1985 should give motivation to our young people. We expect a great deal from this exposition. (Special Technology News Gathering Team)

Industries' Views

Tokyo KOGYO GIJUTSU in Japanese Vol 22 Jan 81 pp 30-31

[Article by Sadakazu Shindo, Chairman, Committee on Industrial Technology, the Japan Federation of Economic Organizations]

[Text] Today, as we enter the 80's Japan is working toward building itself on the basis of technology. In order to achieve long-term stable economic growth and improve the structure of industry, the development of creative independent technology is an urgent task. It is necessary for the entire country to work together to promote innovation.

There has been a strong tendency for our country to depend on foreign imports for the seeds of innovation. We have built up our present economic power chiefly by improving technology for use in mass production. However, from now on, while cultivating more original technology than in the past and working to revolutionize industrial technology, we must make greater contributions to the maintenance and development of international economic society. We must develop technology to break out of the restrictions on resources and energy, and to preserve the environment as well as providing technological cooperation to the developing countries.

The industrial sector, through the Keidanren Industrial Technology Committee, thoroughly studied measures for promoting innovation and put out "Our Views on Promotion of Technological Development" in May 1979 and, together with the

Technology Association, prepared the "Views on Promotion of Technological Innovation." Below I would like to introduce a few of the main ideas from these reports.

Promotion of Lead and Basic Technology Development

Lead technology and basic technology will play a major role in dramatically expanding technological development and nurturing the seeds of innovation to make progress in technological development in many fields. The history of technology demonstrates this, even without the prime example of the Apollo project in the United States. Keidanren took an opinion poll in February 1979 about major technology development issues. It asked which technological fields Japan should emphasize in future development. The questionnaire was given to 165 top executives in charge of technology mainly in manufacturing industries and they were asked for their evaluation of 75 categories of technological development helpful to the long-term advancement of the Japanese economy.

The top fifteen categories selected as a result of the survey as the most important items are shown below grouped according to general areas of technology.

(A) life sciences: (1) basic scientific research (2) application technology for biochemical reactions, etc. (3) anti-cancer and anti-viral agents

(B) energy: (4) reprocessing of spent nuclear fuel (5) radioactive waste disposal (6) solar energy application technology (7) waste-heat application technology and systems (8) energy storage and transport technology

(C) resources: (9) resource cultivation fishing system (10) technology for effective utilization of water resources

(D) new materials: (11) energy conversion substance

(E) electronics and information: (12) light technology (13) new substance

(F) municipal and social: (14) technology for prevention of natural disasters (15) new city traffic system

On the basis of these questionnaire results, Keidanren further evaluated the order of priorities, etc., in the Industrial Technology Committee. As specific fields of lead technology, it chose nuclear power, aerospace, oceans, life sciences, safety and disaster prevention, information, and soft technology and the basis for these, new devices and ultimate materials, as important issues. And it has worked on the government to promote technological development in these fields.

Expansion of Research and Development Funds

Much of our country's technological development has been achieved through the activity of the private sector. However, in lead and basic technology development, there are many areas in which the risk is great and huge amounts of investment are necessary or the market mechanism does not work well. There are built-in limits to what can be done by private investment alone.

Along with greatly expanding the science and technology budget, and increasing the allocation to the private sector, it is desirable to bring in a resilient budget system. Since Japan does not make huge expenditures for arms and aerospace as do other countries so it is often pointed out that we are lacking in technological influence from ultimate technology. Therefore, from now on more active financial cooperation from the government will be necessary in developing lead and basic technology.

In "Our Views on the Promotion of Technological Development," Keidanren asked that the government resolve to double the science and technology budget for three years beginning in 1980 and that the goal set by the Scientific and Technical Council in Report No 5 of April 1971 of expanding research and development funds to 3 percent of the national income be achieved early.

Also, the governments' share of the research expenses used by private enterprise was only 1.7 percent in Japan (1977) compared to 34.9 percent in the United States (1977). It is estimated that the effect of government aid extended to research and development in the private sector is greater than that of public investment. We have also worked hard to get the government to increase the allocation of funds to the private sector by large increases in subsidies and commissions.

Promotion of Creative Science and Technology and Basic Technology for Next-Generation Industry

On the basis of the circumstances mentioned above, the government has announced major policies to be instituted from 1981 on. These include the "Basic Technology Research and Development System for Next-Generation Industry" according to which MITI links the seeds of innovation to practical applications and the "Promotion of Creative Science and Technology" under which the Science and Technology Agency will search out the seeds of innovation. We of the industrial sector believe that this plan is praiseworthy for its extremely good timing. The Keidanren and the Technology Association together prepared the report "Views on Promotion of Technological Innovation" and have worked to have these aims realized.

In these plans we picked out new devices and ultimate materials, as did the Keidanren, as essential basic technology for establishing technologically advanced industry from 1985 on. There are new industrial fields such as the cultivation of biotechnology which can have great influence on future technology and are sufficient causes for great hope. We believe that the industrial sector should cooperate as fully as possible by having superior engineers and technicians participate in these plans.

However, Japan must do its part internationally as a locomotive force in technological innovation, so it is not an exaggeration to say that the execution of these plans is just the first step. A great deal of money and risk will probably be required over the long term to develop innovative technology from now on. Also, it will be necessary to train people especially to link up highly original ideas with creative technological development. With respect to this point, the government will have a great role to play, in addition to its financial role, in creating an effective alliance between government, education, and private business by expanding the opportunities for exchanges between first-line researchers.

In the plans of both MITI and the Science and Technology Agency, the utilization of the research and development capacity of private industry is emphasized. In order for the private sector to actively promote technological innovation it is of course necessary for the industrial executives to be highly motivated and involved. However, the government must give sufficient consideration to the results of research and development in order to bring out the creativity of researchers and produce a large quantity of superior research. In other words, it will be more necessary than in the past to give incentives to the private sector in patent jurisdiction and licensing.

We believe that in Japan the industrial sector must take the leading role in promoting innovation in the future as well as at present. As it does so, it will be essential to strengthen the interaction and organic relationships between government, education, and the private sector and carry out sufficient basic research. The new plans announced by the government to promote technological innovation will be an important test case.

In conclusion, we would like to point out the need to seriously explore the role to be played by science and technology in opening up a more hopeful 21st century, constantly paying attention to the harmony of society as we make progress.

Financial Resources

Tokyo NIKKEI SANGYO SHIMBUN in Japanese 1 Jan 81 p 19

[Article by Kozo Sasaki, Editorial Staff]

[Text] The phrase "building the country on the basis of technology" seems to have taken hold as the path which our country should travel in the 80's. For this purpose, it will be necessary for the government, private sector, and educational establishments to work together even more actively than in the past to promote research and development. Creative research which will produce the seeds of technological innovation is especially needed. This will require large amounts of research and development funds over the long term. The procurement of revenue sources for future research and development is becoming a major issue for this year's science and technology administration.

Private Sector's Burden Heavy in Japan

Total research expenses in Japan for 1979 were 4,080,100,000,000 yen. Of these, the government (national and local public organizations) bore 29.8 percent. The private share continued to be large. In all other advanced countries, the government share is greater than in Japan. It is approximately 50 percent in the United States, the United Kingdom, and France. Even leaving out defense research expenses, their governments' share of R & D expenses is greater than Japan's. The percentage of the GNP (or national income, NI) serves as a yardstick for measuring the amount of research investment. In 1977, it was 1.81 percent. This is higher than other advanced countries.

In response to this situation, the Scientific and Technical Council (advisory body to the Prime Minister) suggested in a report in May of 1977 that the percentage of the NI be increased to 2.5 percent in the near future and to 3 percent over the long term. The Industrial Structure Council (advisory body to the Minister of International Trade and Industry) made an interim report in April 1980 on its vision of MITI policies and specified that the percentage of the GNP spent for R & D should be increased to 2.5 percent in the mid-80's and 3 percent in the late 80's and that the share borne by the government should be increased to at least 40 percent. In May 1979, the Keidanren proposed that the science and technology related budget be doubled over three years beginning in 1980 and the Kankeiren (Kansai Federation of Economic Organizations) proposed in December of last year that the NI percentage should be increased to 3 percent and the government share of research expenses should be doubled. Then at the end of last year, prior to formulation of the 1981 budget, the Science and Technology Cabinet Liaison Committee (chairman, Director General of the Prime Minister's Office Nakayama) specified in their interim report "Concerning the Status of Science and Technology Policies" that the GNP percentage should be increased to 2.5 percent in the near future and 3 percent over the long term. In addition, the Technology Association and the Comprehensive Research and Development Organization have expressed similar views.

4 Trillion Yen for Atomic Energy Program

The scale of future technical development will tend to increase and many issues must be faced which entail risks. Judging from projects in process now, huge expenditures are expected. Atomic energy is expected to be the leading alternative energy source and approximately 4 trillion yen in research and development expenses will be necessary from 1978 to 1997 for the long-term utilization plan for nuclear research and development (established in September 1978). Space development will require approximately 3 trillion yen from 1979 to 1992 (space development set in March 1978). The Sunshine Plan is estimated at 700 billion yen and the Moonlight Plan is also estimated at 700 billion yen.

How much R & D spending is necessary in the future? According to the calculations of the Research Investment Subcommittee of the Scientific and Technical Council the government investment from 1980 to 1990 will be 12 trillion yen. This is an accumulated total of all the R & D expenses to be incurred in the various programs of all the ministries and agencies. To achieve this will require a 21 percent average annual rate of increase in government expenditures. If this happens, the percentage of the NI used for R & D will be 2.8 percent and the government's share of the expenses will be 41 percent, almost meeting the proposals of the various related organizations.

Unless the government expenditures are increased at the rate of 21 percent every year, the necessary R & D expenses cannot be secured. Therefore, it is essential to search for new revenue sources. First, the limits of the budget must be removed at the stage of roughly calculated requests. The 1981 budget was restricted to a growth of 7.5 percent over the previous year. As long as this system exists, we cannot expect a large increase in science and technology promotion expenses from General Accounts.

As new revenue sources, we can consider (1) switching of public corporation revenue sources, (2) expanded object taxes, (3) national science and technology bonds, and (4) utilization of the government investment and loan program. Included in the public corporation revenue sources are special highway revenue sources such as gasoline taxes and automobile weight taxes which are desired by many organizations. They are used for road maintenance and construction, but as of 1979 the percentage of paved roads in Japan was 85 percent so the roads are in rather good condition. Some of this revenue source could be diverted to the science and technology related budget.

Beginning in 1980, an energy related R & D promotion policy was instituted with a power plant development promotion tax and petroleum taxes as revenue sources. This concept could be enlarged to establish (1) a resource consumption tax and (2) an environmental destruction tax. With the resources consumption tax, those who consume exhausted resources would bear the research expenses for developing substitutes for these resources. This is being done in connection with energy now. In addition, users of nickel, cobalt, or manganese, for example, would be made to pay the research expenses for developing manganese deposits lying under deep ocean floors. Also, the environmental destruction tax would tax those (automobile companies, factories, civil engineering and construction businesses, etc.) who perform acts adversely affecting the environment even within the bounds of environmental standards or regulations. It would be used for necessary R & D for environmental preservation.

Issuing Science and Technology Bonds

In addition, former President Tsuchimitsu of Keidanren is suggesting the issue of national science and technology bonds. Under this concept the results of present research on such things as nuclear fusion and cancer will benefit the next generation of the people and these research and development expenses will be justly paid by both the present and the future generation. Briefly, the present construction bonds should be reevaluated, the R & D expenses should be viewed as productive operating expenses from the point of view of the national economy, and part of the construction bonds should be diverted to research investments. Furthermore, the government investment and loan program should be actively utilized, for example, to construct the fast breeder prototype reactor (the Monju), uranium enrichment prototype plant and certified advanced converter reactors.

Japan is proclaiming the building of the country on the basis of technology in the 1980's, but it cannot possibly secure the necessary R & D funds on the basis of previous ways of thinking. Fortunately, the government created the Science and Technology Cabinet Liaison Committee last year, and in the formulation of the 1981 budget, the "Voluntary Committee of Young Diet Members Concerned about Technology" of the LDP asked the government to give special consideration to the science and technology budget. Through this activity, the "promotion of science and technology" was included as one of the five pillars of the LDP budget formulation proposal and the importance of science and technology development is gaining recognition from politicians. So as not to lose this opportunity, this is the year when the Science and Technology Agency, which is responsible for science and technology administration, should act quickly to consider thorough-going policies to secure revenue sources for research and development.

'NIHON KEIZAI SHIMBUN' Editorial

Tokyo NIHON KEIZAI SHIMBUN in Japanese 5 Jan 81 p 2

[Editorial by Hideshi, Hasegawa, Chief, Science & Technology Division]

[Text] Ways to Build Japan on the Basis of Technology in New Environment

The idea of building the country on the basis of technology is loudly proclaimed by both the government and the private sector. In such books as Alvin Toffler's "The Third Wave" and Schreiber's "The World Challenge," Japanese technology has a high international reputation. Why technology now? Maybe it is because in this age of restriction and uncertainty, technology seems to be the only bright point, the only clear hope.

So then, what do the people of Japan expect from technology? What role do they want it to play? If we analyze the reasons and background for the demand to build the country on the basis of technology, the first thing we find is the hope for technological breakthroughs. The economy of the 80's will be trying to stave off problems from all directions. The rest of the world and Japan are similarly deeply troubled by multi-faceted growth-restricting factors such as energy, resources, environment, food, and population. Cannot the ceiling and walls steadily closing in on us be knocked away at one blow with some technological breakthrough like a new energy source? It is probably natural that people look to technology as a way out.

Next is the hope for improvement of daily life. A central breakthrough in large scale technology will not occur for some time but even if the economy is forced to decelerate and grow slowly for a while, we cannot stand a stagnation and suspension of progress in society. If expansion of volume is restricted, we at least want a deeper content and higher quality. Even in a small scale, if we introduce many new and improved technologies in equipment, processes, and labor, added value and productivity will go up and the economy and quality of life will improve. The deterioration of capital plant and equipment can be prevented and international competitiveness can be maintained. Consumers and businessmen both have these kinds of expectations of technology.

Third is the opening of new markets through technology. This is the hope of the industrial sector for a new frontier. Japan is poor in both energy and resources and has no other way of proceeding but to export as a factory for the world. The pressure from friction in foreign markets is building against existing export industries such as shipbuilding, steel, automobiles, and home appliances. Now is the time to put in other players from the bench and we must cultivate new export industries with appealing products and international competitiveness. Even domestically, the demand for old products and services is stabilizing and new products and services must be developed to avoid saturation of the market. Therefore, the seeds of technological innovation are under scrutiny.

Fourth, from the point of view of comprehensive security, there is a demand for securing a right to speak in international affairs, using Japanese technological strength for bargaining power. Japan is a great economic power but limited in resources and military power. It must get recognition for its existence in terms of East-West and North-South issues with technology as the only strength it can call its own. It is expected that, in the future, technology transfer will be an important item in transactions that can be changed into money and goods.

Autonomous Cultivation of Advanced Technology

Now, does advanced technology that could meet these demands actually exist in Japan? One specific example is the VLSI which has been developed with a public and private investment of 70 billion yen and is now bearing fruit in the age of microcomputers. A second example is the program for developing optical industrial technology started with cooperation between government and private industry. It has already resulted in domestic production of the world's longest and best-performing optical fiber. Plans are moving ahead for laying a third Pacific cable on the ocean floor around 1985 using optical fibers. Development of optical computers is even included in the schedule. These are candidates for a new group of industries based on technology.

Technological innovations are also occurring in the area of materials. Chemical raw materials were previously traded in ton quantities. Now new "fine chemicals" for medical use have high added value, up to several million yen per gram. New ceramics are stronger than metals and susceptible to precision shaping. Trial production has begun on ceramic engines for automobiles. The progress in life sciences and biotechnology has potential strength to revolutionize chemistry, medicine, and fermentation. Hope has appeared for mass producing a special drug for virus diseases, interferon, and for controlling cancer.

Nuclear fusion, known as the "no. 4 fire" can take an almost unlimited amount of energy from the ocean. The JT60 in Tokai Mura will attempt to create 100 million degrees of heat. The ocean satellite will be launched in three years for aerial observation of the economic water region which is 12 times the size of Japanese land. Also, the linear motor car, which has been run at 500 kilometers per hour without a driver, will soon be tested with a driver. All of these things have raised the reputation of Japanese technology and they will certainly raise the total strength of our security.

These are only a few examples. If all of the seeds of new technology which are being worked on now or planned in Japan blossom together and bear fruit, it will create a huge surge of technological innovation. There is sufficient strength here to greatly extend the limits of growth. However, seeds alone are not enough. Independent efforts at development are essential to nurture the seeds and make them blossom and bear fruit. This implies increasing government assistance, but Japan is already the third largest research country in the world, behind the United States and the Soviet Union. We should first consider measures for fully utilizing the research resources which we have.

National Concensus for Technology Policy

Japanese research investments are presently estimated at approximately 5 trillion Yen. There are about 600,000 persons involved in research. In both money and personnel, we rank third behind the United States and the Soviet Union. There are not many countries in the world with this much research capacity. Japan has this much responsibility for research not only for our own economy but toward international society. Science and technology research expenses for 1978 were 2.5 percent of the national income. The Scientific and Technical Council's long-term goal of 3 percent should be achieved but it is time that we switched from quantity to quality, to an emphasis on output rather than input. It is important to give more direction to research themes, to motivate researchers, and allocate research expenses selectively.

There is no need to insist on the narrow framework of science and technology expenses. If the subject research is truly original and the technology is innovative there will be many opportunities to apply and test it. There will be no lack of funds, not only for research but for education investment plant and equipment investment, public corporation investment, and funds for application in social welfare and foreign aid. How many technologies can pass the tests of utility, economy, and social relevance and be fully developed in the 80's.

The Japanese like novelty and have been open to new technology but a subtle psychological change has occurred in recent years. The problems of environment and safety and the appearance of test tube babies and DNA exchange have given the average person a vague apprehension about science and technology. What is technology for and who is it for? The real starting point for a new Japan built on the basis of technology is to reevaluate the essential nature of technological civilization.

In Japan, food and clothing are sufficient and over 90 percent of the people feel that they are middle class but if we look carefully around there are many deficiencies and causes of dissatisfaction. We live buried under furniture in small houses that have been likened to rabbit hutches. Every day we ride in shaking commuter trains crowded to 2.37 times capacity where even the holding straps have been mistaken for people. The important issue for technology from now on is to provide and improve not only mass-consumption goods, but social capital and services that are now lacking. If the faith and hope in technology are lost there will be no tomorrow for the Japanese race. So a national concensus on building the nation on the basis of technology must be built through a process of sufficient dialogue and prior evaluation.

Review of Government Programs

Tokyo NIKKAN KOGYO SHIMBUN in Japanese 26 Jan 81 p 1

[Text] Tsukuba Center Focuses on Important Points

The Agency of Industrial Science and Technology of MITI has formulated a policy of beginning soon to reevaluate the content of research in the Tsukuba Research

Center (nine research organs) and the agency's seven testing centers in order to improve the research organization and respond to the need of building the country on the basis of technology. The policy is to clarify the character of the seven testing centers in all parts of the country as nucleus research for facilities for regional technology, bringing out the special characteristics and traditions of each region. The organization of the Tsukuba Research Center was established last March. Each of nine laboratories there does focus research on selected advanced technologies. It is thought that by this selective approach, they can better fulfill their function as the "brain centers" of Japan. A personnel cut was proposed due to financial difficulties, so it was judged necessary for each research organ to do specialized research in its particular field and to avoid redundancy as much as possible between laboratories and testing centers in order to increase the research effectiveness of the Agency of Industrial Science and Technology. There was also a goal of preparing the research organization to respond to the present age of regionalism.

The testing laboratories of the Agency of Industrial Science and Technology are composed of nine research organs which were transferred from Tokyo and its vicinity to the Tsukuba garden city for research, which comprise the Tsukuba Research Center, and the technology testing centers in seven locations throughout the country. Of these, the testing centers in the various regions, the Hokkaido Industrial Development Testing Center and the Tohoku, Nagoya, Osaka, Chugoku, Shikoku, and Kyushu Industrial Technology Testing Centers, have achieved tremendous research results. However, the testing centers rooted in regional characteristics and traditions have a tendency to become weak and their work overlaps a great deal with the research at the Tsukuba Research Center. Even though it seems natural for there to be some overlap in research content, it is necessary to take a new look at policies for utilizing the advantages and special characteristics of the technology testing centers.

The Agency of Industrial Science and Technology has decided that regional characteri'tics can be brought out by selecting core research fields for such testing center--coal related subjects for the Hokkaido testing center, geothermal energy for Tohoku, ceramics for Nagoya, housing for Osaka, ocean development for Chugoku, paper pulp for Shikoku, and synthetic materials for Kyushu. In this way the agency intends to bring out the character of the centers as central research organs for the regions. The Osaka and Nagoya Industry Technology Testing Centers are larger than the others and have a record of results so it will be difficult for them to act as centers concentrating on only one field. However, the policy for actually carrying the measures out, is to investigate the actual situation in each testing center and respect the opinions of people in the centers.

The Tsukuba Research Center, on the other hand, is composed of nine research organs--the measurement laboratory, the machine technology laboratory, the chemical technology laboratory, the microorganism industrial technology laboratory, the high polymer fiber laboratory, the geological survey laboratory, the electronic technology comprehensive laboratory, the product science laboratory, and the pollution and resource laboratory. It aims to be the "brain center" of Japanese industrial technology research. There laboratories were moved completely from the Tokyo area to Tsukuba by last March and all of them are operating smoothly now. In order to further improve the research capacity, the agency says that it will be necessary to narrow the focus on the particular research fields of each laboratory. They will be working at the forefront of their respective fields. The agency policy is to create organic links between all the laboratories and testing centers and construct a research organization which will correspond to both the building of the country on the basis of technology and the age of regionalism.

STA Director General

Tokyo NIKKAN KOGYO SHIMBUN in Japanese 2 Feb 81 p 1

[Interview with Ichiro Nakagawa, Science and Technology Agency Director General--place and date not given]

[Text] [Reporter] The Scientific and Technical Council has been given a budget frame for the first time. I would like to ask what your feeling is about this, Minister.

[Nakagawa] For the first time, the Scientific and Technical Council has received a budget of 3.35 billion yen in science and technology promotion coordinating expenses. This means that the council will have greater coordinating powers and will work actively to promote our country's science and technology. Reasons for this include the large gap between public and private research expenditures for science and technology in comparison with the advanced countries of Europe and the United States and the fact that this lag is becoming evident. Therefore, the suggestion was made to give substantial powers of coordination to the Scientific and Technical Council, the advisory body to the Prime Minister. The Science and Technology Cabinet Liaison Committee also agreed and the plan was carried out. Japan's budget for science and technology is about one trillion yen so in the beginning there were some who felt that the council should get 50 billion yen. But since we were just starting out it was decided to begin with 3.35 billion yen.

[Question] It would seem that actual operations will be difficult.

[Answer] With the cooperation of the Science and Technology Agency; this is under study right now. At any rate, it is a new venture and if it stumbles at this stage it will cause difficulty for future science and technology administration. Therefore, it is necessary to proceed carefully. At the same time, if it functions well, the budget could easily be expanded to 50 or 100 billion yen as in the original conception.

However, if it fails, it is reported that the Ministry of Finance will not provide a budget next year.

The first use of this money will be to promote creative science and technology using a flexible research system and to employ personnel to coordinate and promote special research. The problem is what subjects to choose for research. Probably research will be concentrated on basic research areas in which we are generally considered to be lagging and in research and development at a top international level.

[Question] When it comes to coordination, it will be necessary to obtain the cooperation of the various ministries and agencies.

[Answer] In government offices, battles over jurisdiction and prerogatives always occur. Unless this is controlled it will be impossible to have real research and development. It is important to have competition in carrying out development but unnecessary investment for this purpose should be avoided. If the Scientific and Technical Council has the executive authority for the science and technology promotion budget, it must be obeyed. That's why the Scientific and Technical Council must be set up with coordination powers.

[Question] When exactly will things be made definite?

[Answer] At present, we are making the views of the Scientific and Technical Council members on research subjects and how they are to be allotted. And our office is coordinating this with other ministries and agencies. I believe that things can be decided by March.

[Question] The utilization of private efforts also requires attention, does it not?

[Answer] As an example, the government is providing aid to the Asahi Chemical Industry Company for research and development in uranium enrichment. I believe that the government should go right ahead providing aid as a means of utilizing the activity of the private sector. Also, creative science and technology should be promoted by the public and private sectors working together, this can be done through the flexible research system involving government, education, and private enterprise which will begin operating in 1981.

[Question] However, just throwing out money is not enough. It is important to produce results.

[Answer] That's right. This must be dealt with carefully. However, some waste is necessary in research and development. A completely rational approach that says that the government should not get involved in a particular kind of research because it is being handled by the educational institutions is bad. Here is where coordination becomes important.

[Question] How well is present science and technology understood?

[Answer] When we consider the development of nuclear power, space, and the oceans, we know that a great deal of technological expertise and knowledge is necessary. Science and technology is very closely related to the life of the nation but some aspects of it are difficult to understand. The Science and Technology Agency has a similar role to the masked stagehands in the Kabuki theater. The people who direct the actor's movements and arrange the stage settings so that the actors perform well have a great deal of power and this is the role of the Science and Technology Agency.

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CSO: 4105

SCIENCE AND TECHNOLOGY

ASPECTS OF LASER PLASMA RESEARCH DISCUSSED

Plasma Counter-Streams

Nagoya NUCLEAR FUSION RESEARCH in Japanese Vol 39, No 1 [no date given], pp 101-107

[Article by Masamitsu Aizawa of the Faculty of Science, University of Tokyo: "Counter-Streams in Laser-Induced Plasma"]

[Text] 1. Introduction

An effective means to supply plasma to a magnetic container is to drop pellets into a vacuum container, then directing a plasma beam at the pellets to form the plasma in a practice which is sometimes used.[1]

As the magnetic container is made larger, a limit is reached in the quantity of plasma which can be generated per pass, and it may be necessary to resort to multiple point formation.

When such a practice is adopted, there will necessarily be collisions between separate plasmas. It would be desirable to minimize instability in order to provide stable plasma.

This paper will describe plasma counter-streams in the collisionless region based on experimental studies which were conducted at the Sekuguchi Laboratory.

2. Plasma Stream in a Homogeneous Magnetic Field

According to certain experiments,[2] plasma is generated by direction Nd-glass laser of 2 GW peak power and 20 nsec pulse width on a beryllium wire target in a homogeneous magnetic field. Measurements by the soft x-ray method indicate the average electron temperature during laser irradiation to be about 300 eV.

(It is thought that this is about T_e-T_i.)

As a result, there is fairly good thermal conduction in the direction parallel to the magnetic field, and the flow is roughly one-dimensional, while temperature changes take place in an adiabatic manner. This is why the thermal energy of the ions is converted to kinetic energy together with the flow, and the kinetic energy of the plasma can be thought to be roughly the energy acquired by the ions. Measurements by the Thomson scattering method using laser show the electron temperature to be about 30 eV approximately 6 cm from the point of formation (300 nsec after generation), and the ion temperature is about 1/10 this value.

3. Simulation Model

A super particle model by the differencing twin pole method was adopted.[3,4] The plasma flow along the magnetic field up to 300 nsec can be considered roughly uniform to 1-6 cm from the point of generation according to the experimental evidence given in Paragraph 2. Here we will examine the most simple situation in which there is spacewise uniformity.

1) These particles have shape with spread of $Q(x) = q \cdot S(x)$ (q: total charge). Here $S(x)$ is a shape factor which satisfies the following equation, and a Gaussian form is used.

$$\int S(x)\, dx = 1 \tag{1}$$

The plasma formed by the laser will be assumed to flow essentially without charge separation, and it will be further assumed that the ions and electrons both possess shifted Maxwell distribution. That is to say, we consider the following two cases:

<Case 1>

$$f_e(V) \rightarrow e^{-\frac{(V-V_{de})^2}{2V_{te}^2}} + e^{-\frac{(V+V_{de})^2}{2V_{te}^2}} \tag{2-a}$$

$$f_i(V) \rightarrow e^{-\frac{(V-V_{di})^2}{2V_{ti}^2}} + e^{-\frac{(V+V_{di})^2}{2V_{ti}^2}} \tag{2-b}$$

<Case 2>

$$f_e(V) \rightarrow e^{-\frac{(V-V_{de})^2}{2V_{te}^2}} + e^{-\frac{(V+V_{de})^2}{2V_{te}^2}} + P\cdot e^{-\frac{V^2}{2V_{deb}^2}} \tag{3-a}$$

$$f_i(V) \rightarrow e^{-\frac{(V-V_{di})^2}{2V_{ti}^2}} + e^{-\frac{(V+V_{di})^2}{2V_{ti}^2}} + P\cdot e^{-\frac{V^2}{2V_{dib}^2}} \tag{3-b}$$

Here we assume the density of the plasma flow in the flux to the opposite direction to be roughly the same. P is a parameter which displays the distribution ratio. The values of these parameters are listed in [Table 1].

Simulation parameter values are given in [Table 2]. The primary and secondary moments for each distribution have been corrected.[4] At the same time, as shown in [Fig 1], this model can be considered to be that of a collisionless plasma in the time region under consideration.

Next, by considering the following quantity in terms of the electron, we can establish a parameter for the state of instability of the system.

$$R(t) = \frac{\langle V(t)\rangle^2 - \langle (V(t))^2\rangle}{\langle V(0)\rangle^2 - \langle (V(0))^2\rangle} \tag{4}$$

The < > in equation (4) indicates an average over velocity space.

4. Results

The changes in electric field excited by the plasma in the situation when there was no background plasma were plotted every $2\omega_{pe}^{-1}$, and this plot is shown in [Fig 2a]. This phase space situation is shown in [Fig 2b]. Next, we consider the situation in which there is plasma which can be considered to be background present in the magnetic container (Case 2) and treat the situation in which this background plasma and the plasma generated are about the same quantity ($P \approx 1$ in equation [3]). As shown in [Fig 3c], it is evident that the predicted results were obtained. The time development of parameter R(t) described in Paragraph 3 is shown in [Fig 4 a-b]. [Fig 4a] and [Fib 4b] correspond to (Case 1) and (Case 2) respectively.

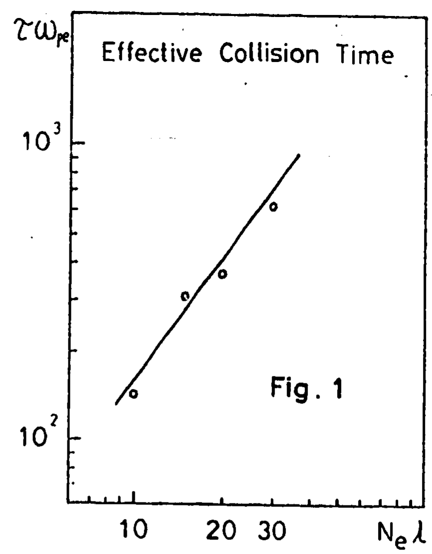


Fig. 1

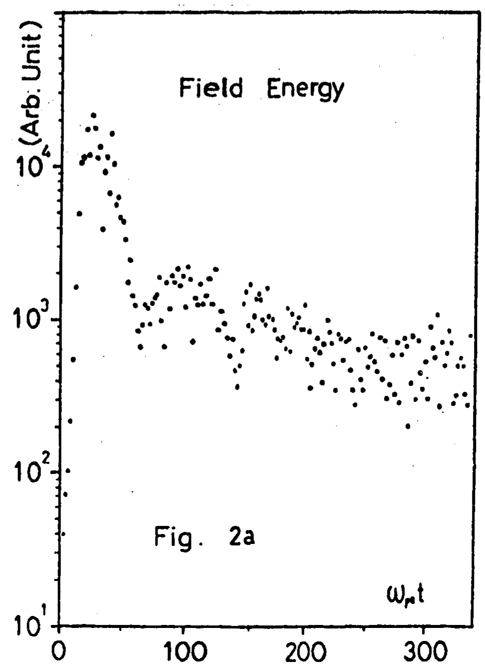

Field Energy
(Arb. Unit)
10^4
10^3
10^2
10^1
0
100
200
300
ωpt

Fig. 2a

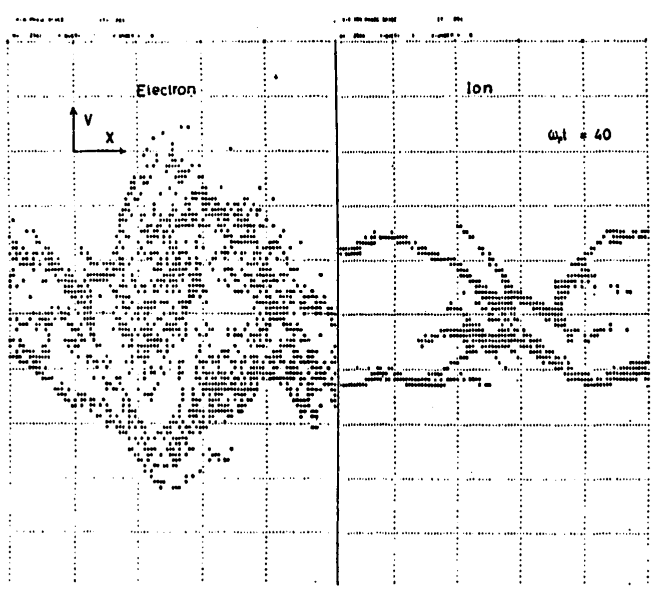
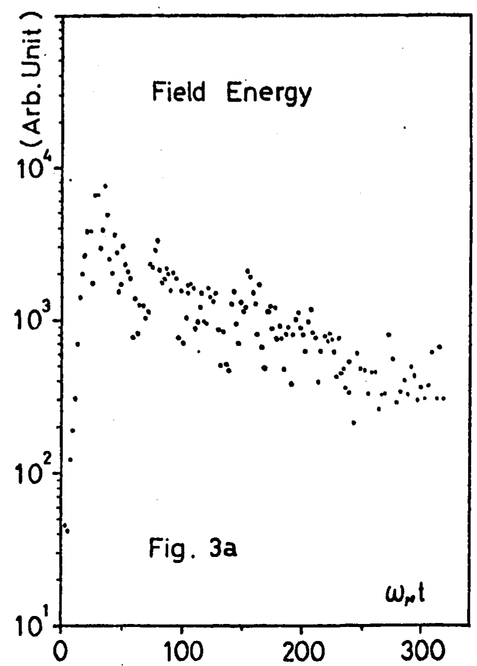

Electron
Ion
v
x
ωpt = 40

Fig. 2b


(Arb. Unit)
Field Energy
10^4
10^3
10^2
10^1
Fig. 3a
$\omega_{pe}t$
0
100
200
300

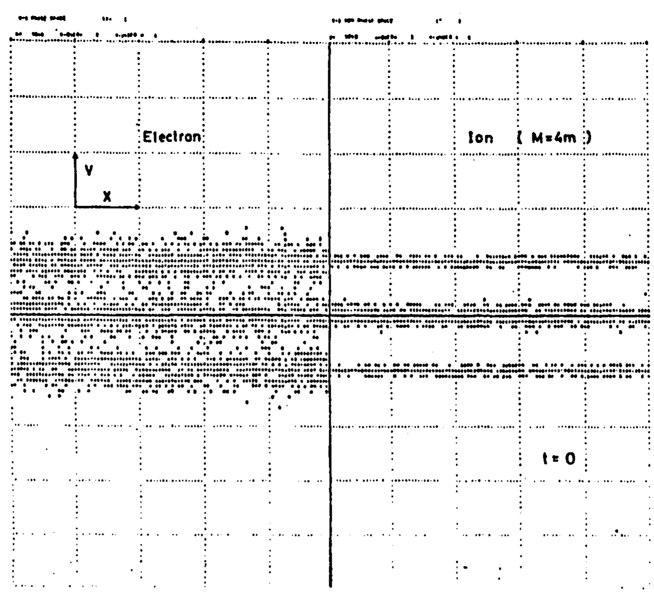

Electron
Ion (M=4m)
v
x
t=0

Fig. 3b

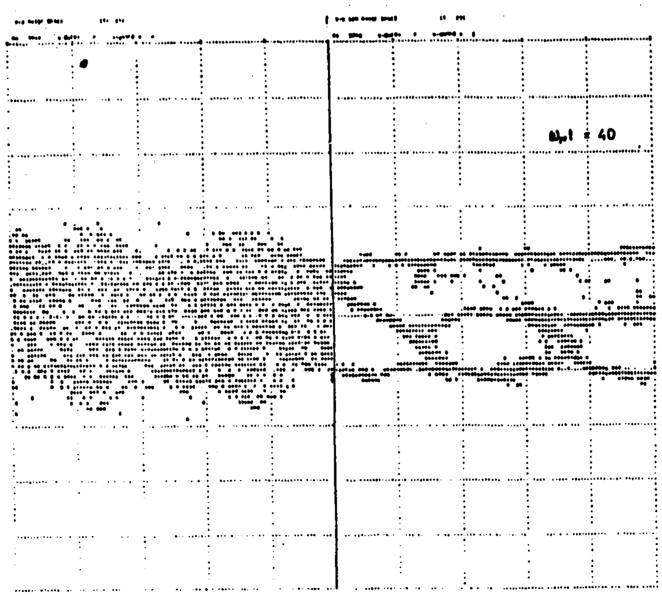


Fig. 3c

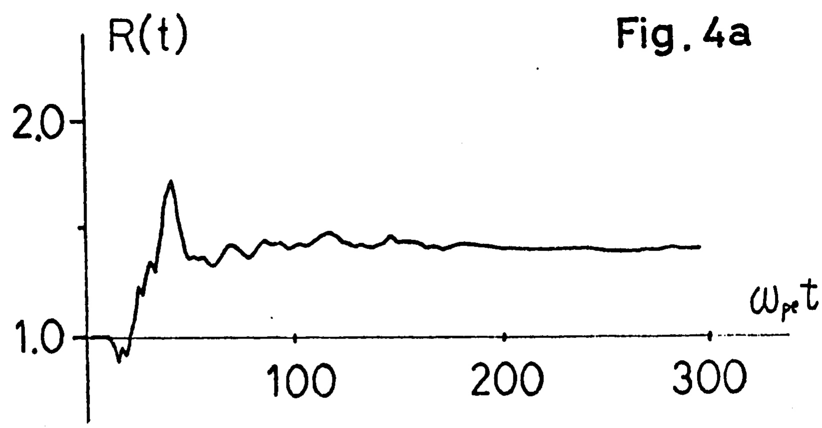
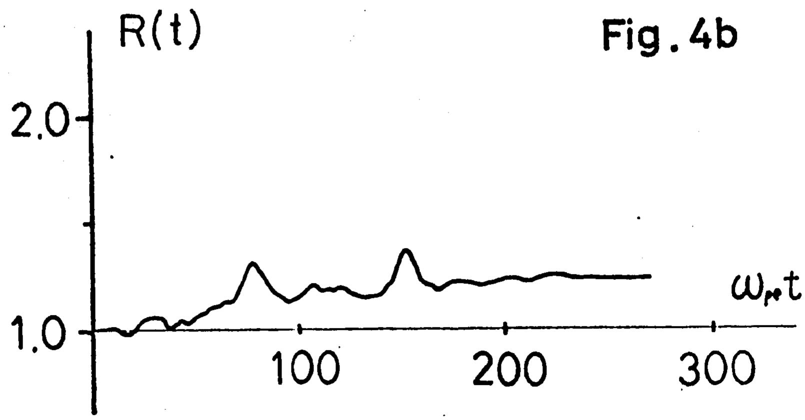


Fig. 4a



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Magnetic Field Generation

Nagoya NUCLEAR FUSION RESEARCH in Japanese Vol 39, No 1, pp 153-163

[Article by Toshio Okada of the Faculty of Engineering, University of Agricultural Engineering, and Takashi Yabe and Keishiro Tansei of Tokyo Institute of Technology: "Abnormal Thermal Conduction Due to Electromagnetic Instability"]

[Text] 1. Introduction

The generation of a strong self-induced magnetic field from within the plasma has been observed in a laser plasma. There has been to date much research from various standpoints related to the mechanism of the generation of this magnetic field, and we were able to elucidate this mechanism in relationship to the Weibel Instability. Furthermore, we analyzed the effects of this self-generated magnetic field on transport phenomena within the plasma, particularly on the thermal conductivity index, through the quasi linear theory approach and compared the results with a simulation by the PIC method.

2. Basic Equation and Linear Theory

The so-called Weibel Instability can be considered a possible mechanism for the generation of the self-induced magnetic field in a plasma. This is an instability which occurs when a temperature anisotropy is created within the plasma, and this situation is considered to be the most hazardous case for lateral waves. It is thought that this instability also has great effect on transport processes within the plasma. We will start off from the following linearized plasma equation in the analysis of Weibel Instability in laser plasma.

$$\frac{\partial f_1}{\partial t} + V\frac{\partial f_1}{\partial r} + \frac{q}{m}\left(E_1 + \frac{1}{c}V\times B_1\right)\cdot\frac{\partial f_0}{\partial V} = 0 \qquad (1)$$

Here f_0 is the unperturbed distribution function of the electron, f_1 is the perturbed distribution function, and E_1 and B_1 are the excited electric field and magnetic field respectively. Also, q and m are the charge and mass of the electron and c is the velocity of light.

We assume the following distribution function which takes into account the influences of small numbers of high speed electrons which have been experimentally demonstrated in plasma laser to be used as the unperturbed distribution function f_0.

$$f_0 = n\left(\frac{m}{2\pi\kappa T_\perp^c}\right)\left(\frac{m}{2\pi\kappa T_x^c}\right)^{1/2}(1-\alpha)\exp\left(-\frac{m(v_x+v_d^c)^2}{2\kappa T_x^c} - \frac{mv_\perp^2}{2\kappa T_\perp^c}\right)$$

$$+ n\left(\frac{m}{2\pi\kappa T_\perp^h}\right)\left(\frac{m}{2\pi\kappa T_x^h}\right)^{1/2}\alpha\exp\left(-\frac{m(v_x-v_d^h)^2}{2\kappa T_x^h} - \frac{mv_\perp^2}{2\kappa T_\perp^h}\right), \qquad (2)$$

Here n is the electron density, κ is the Boltzman constant, T is temperature, T_x is the temperature in the x direction, $T_\perp$ is the temperature in the direction normal to x, v_d is the drift rate, α is the fraction of high speed electrons, suffix c denotes low temperature electrons, and h denotes high speed electrons.

Assuming that the perturbation in equation (1) is proportional to exp $[i(K\cdot r - \omega_t)]$, the following distribution function can be derived for the lateral waves using equations (1), (2), and the Maxwell equations.

(A) When the wave number spectrum K is selected in the y direction, (mode A), the dispersion related equation assumes the following form.

$$\omega^2 - (c^2k^2 + \omega_p^2) + \left\{\omega_p^2(1-\alpha)\frac{T_x^c}{T_\perp^c} + \omega_p^2(1-\alpha)\frac{mv_d^{c^2}}{T_\perp^c}\right\}W\left(\frac{\omega}{k\sqrt{\frac{\kappa T_\perp^c}{m}}}\right)$$

$$+\left\{\omega_p^2\alpha\frac{T_x^h}{T_\perp^h} + \omega_p^2\alpha\frac{mv_d^{h^2}}{T_\perp^h}\right\}W\left(\frac{\omega}{k\sqrt{\frac{\kappa T_\perp^h}{m}}}\right) = 0, \qquad (3)$$

Here ω_p is the plasma vibration number of the electron and the function W is defined in the following manner.

$$W(\xi) = (2\pi)^{-1/2} \int_{-\infty}^{\infty} \frac{\zeta}{\zeta - \xi} \exp(-\zeta^2/2)\, d\zeta. \tag{4}$$

At the extreme limits of $\left|\omega/k\sqrt{\frac{\kappa T_\perp^c}{m}}\right| < 1$, $\left|\omega/k\sqrt{\frac{\kappa T_\perp^h}{m}}\right| < 1$,

equation (3) can be solved in the following approximate form.

$$\omega_r = 0 \tag{5}$$

$$\gamma = \sqrt{\frac{2}{\pi}} \left[(1-\alpha) \frac{\kappa T_x^c + m v_d^{c\,2}}{\kappa T_\perp^c} + \alpha \frac{\kappa T_x^h + m v_d^{h\,2}}{\kappa T_\perp^h} - 1 - \frac{c^2 k^2}{\omega_p^2} \right]$$

$$\times \left[(1-\alpha) \frac{\kappa T_x^c + m v_d^{c\,2}}{\kappa T_\perp^c \, k\sqrt{\kappa T_\perp^c/m}} + \alpha \frac{\kappa T_x^h + m v_d^{h\,2}}{\kappa T_\perp^h \, k\sqrt{\kappa T_\perp^h/m}} \right]^{1}, \tag{6}$$

Here we let $\omega = \omega_r + i\gamma$.

From equations (5) and (6), the wave number region where instability occurs is the following:

$$k^2 < \frac{\omega_p^2}{c^2} \left[(1-\alpha) \frac{\kappa T_x^c + m v_d^{c\,2}}{\kappa T_\perp^c} + \alpha \frac{\kappa T_x^h + m v_d^{h\,2}}{\kappa T_\perp^h} - 1 \right] \tag{7}$$

The growth rate is maximum at the following wave number:

$$k^2 = \frac{1}{3} \frac{\omega_p^2}{c^2} \left[(1-\alpha) \frac{\kappa T_x^c + m v_d^{c\,2}}{\kappa T_\perp^c} + \alpha \frac{\kappa T_x^h + m v_d^{h\,2}}{\kappa T_\perp^h} - 1 \right] \tag{8}$$

(B) When the wave number vector K is selected in the x direction (mode B), the distribution functional equation takes the following form:

$$\omega^2 - (\omega_p^2 + k^2 c^2) + \frac{(1-\alpha)\,\omega_p^2 T_\perp^c}{T_x^c} W\left(\frac{\omega + k v_d^c}{k\sqrt{\kappa T_x^c/m}} \right)$$

$$+ \frac{\alpha\,\omega_p^2 T_\perp^h}{T_x^h} W\left(\frac{\omega - k v_d^h}{k\sqrt{\kappa T_x^h/m}} \right) = 0 \tag{9}$$

At $|(\omega + k v_d^c)/k\sqrt{\kappa T_x^c/m}| < 1$, $|(\omega - k v_d^h)/k\sqrt{\kappa T_x^h/m}| < 1$ the solution of equation (9) is as follows:

$$\omega_r = k \left[\alpha \frac{T_\perp^h v_d^h}{T_x^h \sqrt{\kappa T_x^h/m}} - (1-\alpha) \frac{T_\perp^c v_d^c}{T_x^c \sqrt{\kappa T_x^c/m}} \right]$$

$$\left[\alpha \frac{T_\perp^h}{T_x^h \sqrt{\kappa T_x^h/m}} + (1-\alpha) \frac{T_\perp^c}{T_x^c \sqrt{\kappa T_x^c/m}} \right]^{-1}, \tag{10}$$

$$\gamma = \sqrt{\frac{2}{\pi}}\, k \left[\alpha \frac{T_\perp^h}{T_x^h} + (1-\alpha) \frac{T_\perp^c}{T_x^c} - \frac{k^2 c^2}{\omega_p^2} - 1 \right] \left[\alpha \frac{T_\perp^h}{T_x^h \sqrt{\kappa T_x^h/m}} \right.$$

$$\left. + (1-\alpha) \frac{T_\perp^c}{T_x^c \sqrt{\kappa T_x^c/m}} \right]^{-1}. \tag{11}$$

Instability occurs in the following wave length region:

$$k^2 < k_0^2 = \frac{\omega_p^2}{c^2} \left[(1-\alpha) \frac{T_\perp^c}{T_x^c} + \alpha \frac{T_\perp^h}{T_x^h} - 1 \right]. \tag{12}$$

The maximum growth rate is given by the following equation:

$$\gamma_M = \sqrt{\frac{8}{27\pi}}\, \frac{\omega_p}{c} \left[(1-\alpha) \frac{T_\perp^c}{T_x^c} + \alpha \frac{T_\perp^h}{T_x^h} - 1 \right]^{\frac{3}{2}}$$

$$\times \left[(1-\alpha) \frac{T_\perp^c}{T_x^c \sqrt{\kappa T_x^c/m}} + \alpha \frac{T_\perp^h}{T_x^h \sqrt{\kappa T_x^h/m}} \right]^{-1}. \tag{13}$$

3. Quasi Linear Theory

We will develop a quasi linear theory in order to handle the effect of electromagnetic instability on thermal conductivity. The basic equations are the Vlasov equation and the Maxwell equation shown below.

$$\frac{\partial f}{\partial t} + \mathbf{V} \cdot \frac{\partial f}{\partial \mathbf{r}} + \frac{q}{m} (\mathbf{E} + \frac{1}{c} \mathbf{V} \times \mathbf{B}) \cdot \frac{\partial f}{\partial \mathbf{V}} = 0 , \tag{14}$$

$$\nabla \times \mathbf{E} = -\frac{1}{c} \frac{\partial \mathbf{B}}{\partial t} , \tag{15}$$

$$\nabla \times \mathbf{B} = \frac{1}{c} \frac{\partial \mathbf{E}}{\partial t} + \frac{4\pi \mathbf{j}}{c} . \tag{16}$$

In the above equations f is the distribution function of the electron and j is the current density.

An ensemble average is indicated by < >, and expressing the potential by δ from this average quantity leads to the following equations from equation (14).

$$\frac{\partial \langle f \rangle}{\partial t} + \mathbf{V} \cdot \frac{\partial \langle f \rangle}{\partial \mathbf{r}} + \frac{q}{m} \langle (\delta \mathbf{E} + \frac{1}{c} \mathbf{V} \times \delta \mathbf{B}) \cdot \frac{\partial \delta f}{\partial \mathbf{V}} \rangle = 0 , \tag{17}$$

$$\frac{\partial \delta f}{\partial t} + \mathbf{V} \cdot \frac{\partial \delta f}{\partial \mathbf{r}} + \frac{q}{m} (\delta \mathbf{E} + \frac{1}{c} \mathbf{V} \times \delta \mathbf{B}) \cdot \frac{\partial \langle f \rangle}{\partial \mathbf{V}} = 0 . \tag{18}$$

Equation (15) takes the following form:

$$\nabla \times \delta \mathbf{E} = -\frac{1}{c} \frac{\partial \delta \mathbf{B}}{\partial t} . \tag{19}$$

The assumption was made that <E> = 0 and <B> = 0 in the above series of equations.

Equation (17) takes the following form in the case of mode A.

$$\frac{\partial \langle f \rangle}{\partial t} + \mathbf{V} \cdot \frac{\partial \langle f \rangle}{\partial \mathbf{r}} - i \omega_p^2 \sum_k \frac{|\delta B_k|^2}{4\pi n m c^2 k^2} \left[k v_x \frac{\partial}{\partial v_y} - (\omega_k + k v_y) \frac{\partial}{\partial v_x} \right] \left[\frac{k v_x}{\omega_k - k v_y} \frac{\partial}{\partial v_y} + \frac{\partial}{\partial v_x} \right] \langle f \rangle , \tag{20}$$

Here δB_k is the Fourier component of the induced magnetic field in the Z direction.

Assuming equation (2) to be <f>, the third moment of equation (20) was obtained in the following approximate manner.

$$\frac{\partial Q}{\partial t} + \frac{n T_a}{m} \frac{\partial T_a}{\partial x} \approx -\sqrt{\frac{\pi}{2}} \sum_k \frac{|\delta B_k|^2}{4\pi n m c^2} \frac{\omega_p^2}{k v_{Tya}} \left(\frac{w}{v_{Tya}} \right)^2 Q = -\nu_Q Q , \tag{21}$$

Here we let

$$T_x^c\ T_\perp^c\ T^c,\ T_x^h\ T_\perp^h\ T^h,\ w\ [\ \frac{\sqrt{2}\pi}{6}\sum_k\ (|\delta B_k|^2/4\pi\ nmc^2)\ (v_{Tya}\omega_p/k)^2]^{1/4}$$

In the above v_{T_y} is the thermal velocity in the y direction, and Q is defined in the following manner:

$$Q = \frac{m}{2}\int v_x\ (v_x^2 + v_y^2)\ \langle f\rangle d^2\ V \tag{22}$$

The subscript a is the average of low and high temperature electrons.

Under steady state condition ($\partial/\partial t = 0$), thermal flux Q is represented as follows:

$$Q = \frac{nT_a}{m\nu_Q}\ \frac{\partial T_a}{\partial_x} = -K_{eff}\ \frac{\partial T_a}{\partial_x} \tag{23}$$

K_{eff} is the effective thermal conductivity coefficient as influenced by the induced magnetic field.

Alternately, the equation to which the thermal flux from mode B confirms is the following:

$$\frac{\partial Q}{\partial t} + \frac{nT_a}{m}\ \frac{\partial T_a}{\partial x} \simeq -\sqrt{18\pi}\ \sum_k\ \frac{|\delta B_k|^2}{4\pi nmc^2}\ \frac{\omega_p^2}{kv_d^h}\ \frac{v_{Ty}^{h^2}}{v_{Ty}^{h^2}} \tag{24}$$

$$\times\frac{\omega_r - kv_d^h}{kv_{Tx}^h}\ Q \simeq -\nu_Q'\, Q\,,$$

Here it was assumed that $v_{Ty}^h(\simeq v_{Tx}^h \simeq v_d^h) > v_{Ty}^c(\simeq v_{Tx}^c \simeq v_d^c)$.

The following equation was derived for the effective thermal conduction index:

$$K_{eff}' = \frac{nT_a}{m\nu_Q'}\ . \tag{25}$$

4. Simulation and Discussion

The code used here to simulate the Weibel Instability was a one-dimensional space, two-dimensional velocity space PIC electromagnetic code. The induced electromagnetic field was taken to be $E = (E_x, E_y, 0)$, $B = (0, 0, B_z)$. The length of the region under consideration is $35.2\ c/\omega_p$, there are 64 Euler cells of $0.55\ c/\omega_p$ width, and there are 16 simulation particles (S.P.) per cell for a total of 1,024 particles. The ions serve as fixed neutralizing background. The wave equation is solved over Fourier space, and the time step for difference is $\Delta t = 0.2\ \omega_p^{-1}$.

A parameter of the type shown below is selected to perform mode A simulation.

$$v_{Tcx} = v_{Tcy} = 0.05\,c,\quad v_{Thx} = v_{Thy} = 0.25\,c,$$
$$v_d^c = 0.04\,c,\quad v_d^h = 0.2\,c,\quad \alpha = \frac{1}{6}\,. \tag{26}$$

The induced magnetic field component at $kc/\omega_p = 0.54$ is shown in Figure 1, and a linear growth rate determined from this figure was $0.01\ \omega_p$. On the other hand, the growth rate obtained by linear theory is $0.009\ \omega_p$, and there is good agreement between the simulation value and theory. The strength of the induced magnetic field is shown in Figure 2, and the average value of the magnetic field at the saturation level is $B_{sat} \sim 10^{-1}\sqrt{4\pi mnc^2}$. Because of the similarity to the captured electron frequency in the case of static electrons, substituting VB/c in place of the electric field leads to a magnetic capture frequency ω_B which is the following:

$$\omega_B = \sqrt{\frac{keVB}{mc}} \sim 0.015\,\omega_p\ (V = 0.05\,c) \tag{27}$$

When this value is compared to the linear growth rate $\gamma = 0.01\ \omega_p$, it becomes clear that saturation of the magnetic field is taking place at $\omega_B \sim \gamma$. The respective energies are displayed in Figure 3, and this figure displays the pattern by which low temperature electrons and high temperature electrons are interposed. It can also be seen from the graph of total energy in the x and y directions that energy anisotropy has been completely smoothed out. The time changes in thermal flux are shown in Figure 4, and the attenuation rate of this thermal flux ν_Q from this figure is the following.

$$\nu_Q \sim 10^{-3}\ \omega_p \tag{28}$$

Should the saturation level of the induced magnetic field be the result of magnetic capture, ν_Q will have a value of $10^{-3}\omega_p$ even by theory. By substituting 1/L in place of $\partial/\partial x$ and ω_p/c for k in equation (23) to obtain abnormal attenuation rates in thermal flux, the following form is obtained.

$$Q = n\varepsilon v_T f \tag{29}$$

Here ε is the average thermal energy, and f is the thermal conductivity attenuation rate by classical theory. Substituting $\varepsilon = 1$ keV, $n = 10^{22}\text{cm}^{-3}$, $L = 10\ \mu$, and $B^2/4\pi nmc^2 = 10^{-2}$, the value given below was obtained.

$$f \sim 10^{-3}, \tag{30}$$

The following parameter is selected for mode B

$$v_{Tcy} = 0.05\,c,\quad v_{Thx} = 0.2\,c,\quad v_{Thy} = 0.25\,c,\quad v_d^c = 0.03\,c,$$
$$v_d^h = 0.15\,c,\quad \alpha = \frac{1}{6}\,. \tag{31}$$

The magnetic field component for instability mode $kc/\omega_p = 0.43$ is plotted in Figure 5, and this figure displays an initial growth rate of 0.01 ω_p. The growth rate by linear theory is 0.008 ω_p, and there is good agreement between simulation and theory. The magnetic field at the saturation level from Figure 6 is $B_{sat} \sim 10^{-1}\sqrt{4\pi mnc^2}$. The magnetic capture frequency ω_B is

$$\omega_B = \sqrt{\frac{keVB}{mc}} \sim 0.015\,\omega_p\ (V = 0.05\,c) \tag{32}$$

and here again $\omega_B \sim \gamma$ is satisfied.

The respective energies are shown in Figure 7, and the energy change patterns are shown.

The attenuation rate in thermal flux ν'_Q of the following value

$$\nu'_Q \sim 10^{-2}\ \omega_p \tag{33}$$

is obtained from Figure 8. The ν'_Q value from theory is $10^{-2}\omega_p$. Selecting the following parameters of $\varepsilon = 1$ keV, $n = 10^{22}\text{cm}^{-3}$, $L = 10\ \mu$, and $B^2/4\pi nmc^2 = 10^{-2}$ results in the following,

$$f \sim 10^{-4} \tag{34}$$

and it is seen that there is greater attenuation in thermal flux than in mode A.

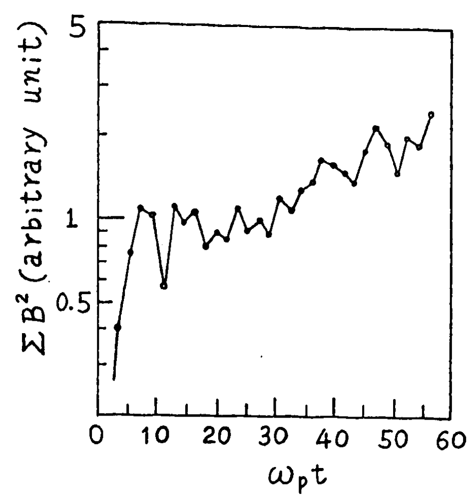


Fig. 1

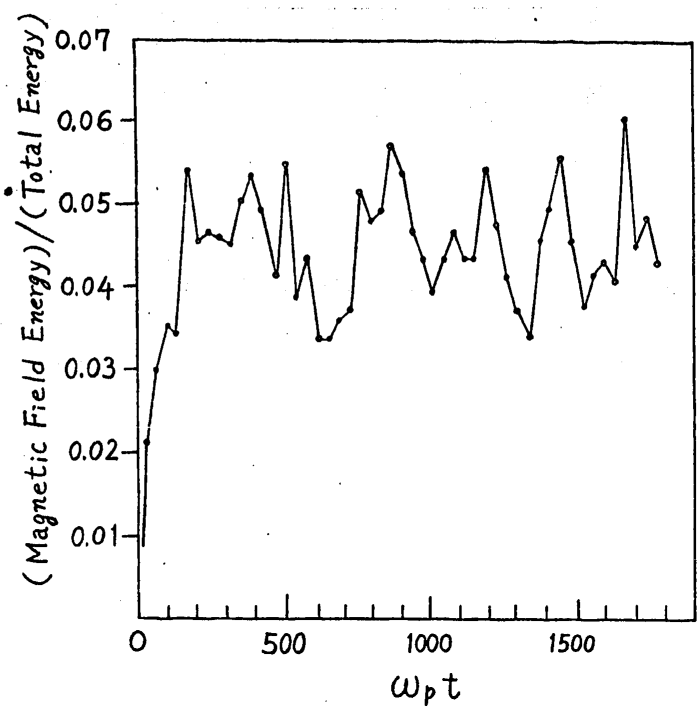


Fig. 2

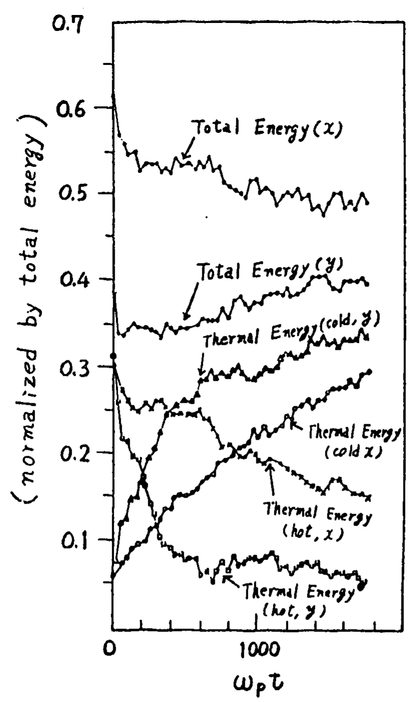


Fig. 3

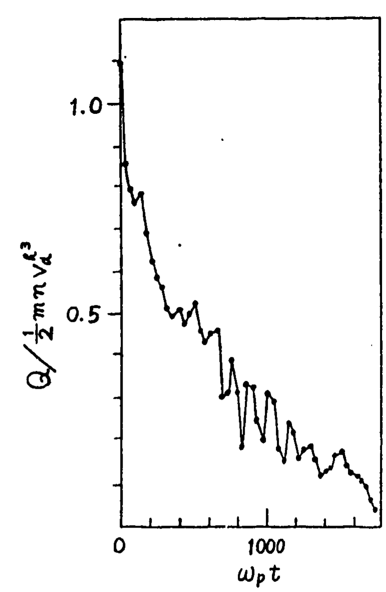
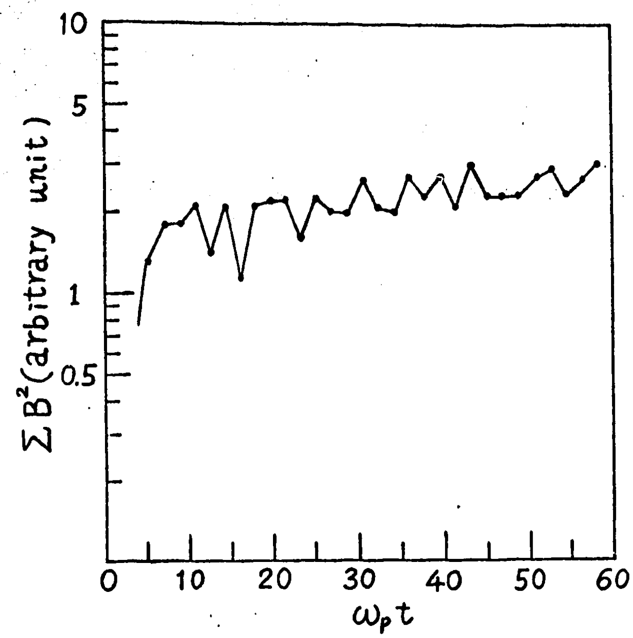
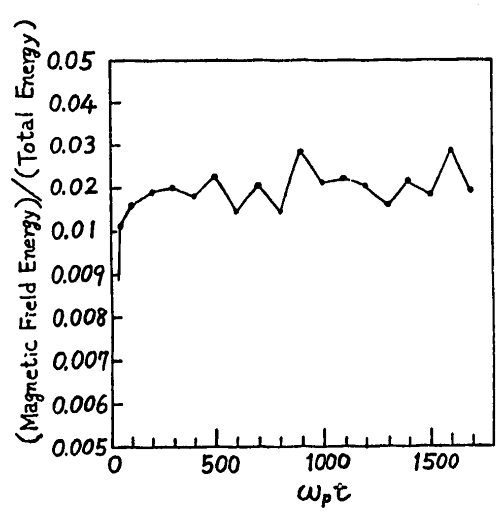


Fig. 4



10
5
1
0.5
ΣB^2(arbitrary unit)
0
10
20
30
40
50
60
$\omega_p t$

Fig. 5



(Magnetic Field Energy)/(Total Energy)
0.05
0.04
0.03
0.02
0.01
0.009
0.008
0.007
0.006
0.005
0
500
1000
1500
$\omega_p t$

Fig. 6

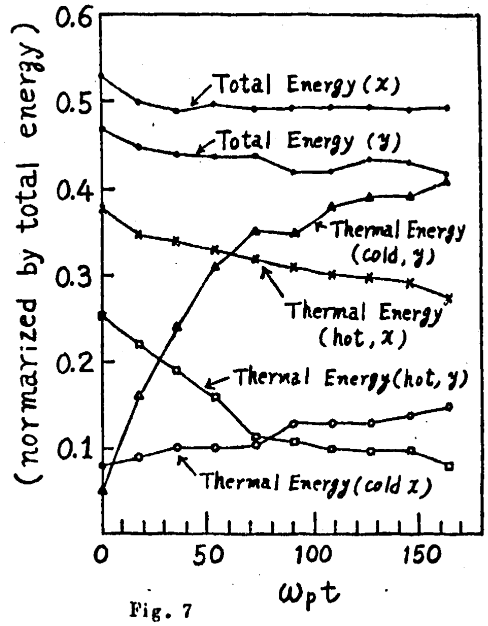


Fig. 7

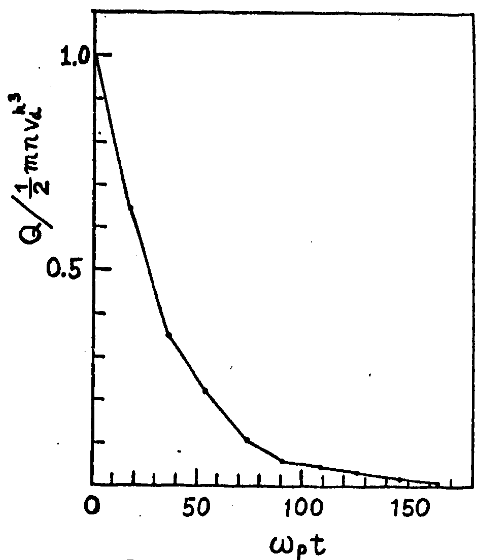


Fig. 8

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SCIENCE AND TECHNOLOGY

ROLE OF AUTOMATION TECHNOLOGY IN PLANTS TODAY, IN FUTURE

Tokyo NIKKEI SANGYO SHIMBUN in Japanese 22 Jan 81 pp 14-21

[Articles by two university professors and three industrialists on present status and future of industrial automation; first article is by Yuji Yoshikawa, Assistant Professor of Engineering, Tokyo Metropolitan University]

[Text] The Role of Large, Numerically Controlled Process Technology

According to the automata theory of the famous mathematician and physicist Dr von Neumann, a completely unmanned factory in which a required number of machines are manufactured by the machine by its self-multiplication capability is not totally illusory, even though realization of such a factory is not expected in the near future. Now then, what is the present state of "unmannization?" In order to turn out a machine, at least it must be manufactured according to a design. Automation of the design process is due to CAD (computer-aided design), while for unmannization of the manufacturing process it is CAM (computer-aided manufacturing). An unmanned factory, in a broad sense, is a factory in which all functions, including design, manufacture, management, and storage, are automated. In a narrow sense, as it is generally understood today, it refers to the "unmanned manufacturing process." That is, the number of human operators engaged in processing and assembly on site is to be reduced by means of automation, ultimately eliminating human operators completely. The action of the machines which undertake processing and assembly must of course follow human commands of one form or another, but the work goes on in an unmanned factory even in the absence of the human operator. In this sense it is probably more accurate to call such a factory an "unattended factory."

As a means of achieving "unmannization," one cannot neglect the role played by NC (numerically controlled) process technology. This is an automatic process mode that is controlled by a computer according to digital data prepunched on a tape describing the locus of motion of the tool and work actuated by the movement of a handle turned by an operator. Since the work process is instructed by a tape, there are many advantages, including the fact that there are no fluctuations in the precision of finish due to different individual operators; complicated curved surfaces can be manufactured automatically; different works can be processed simply by changing the tape, making the operation quite flexible; and the operation can be carried out efficiently with the adoption of a multistation operation format. On account of these advantageous points, NC technology has experienced an explosive growth in Japan during the past decade. According to 1979 statistics, approximately

40 percent of all machine tools sold belonged to NC machines, and in the case of lathes it was 50 percent. In England, only 17 percent of the lathes manufactured belonged to NC machines. The reasons why NC machines have become so popular in Japan include the recognition by capital of the potential for rationalization of NC machines, intertwined with a conscious desire by labor to be liberated from simple mechanical operations and a sense of crisis shared by both capital and labor that unless products having high added value are manufactured, the entire Japanese industry may go to the bottom. In the United States, the popularization of NC machines is not as widespread as in Japan, thanks in part to the steadfast opposition to rationalization by the functionally divided labor unions, while in Europe it is not too much to say that they have not yet freed themselves from the master craftsman concept.

Now then, the decision concerning whether or not to aim for "unmannization" depends first of all on its effect on society, especially with regard to the number of employees and the skill of the labor force. In England and West Germany, this problem is being investigated today as a link in their national project. In Japan, however, this type of investigation has never been conducted, even in those large-scale projects being carried out today. Therefore, Japan has been criticized by some European nations for creating confusion by attempting rationalization and unmannization not only in the field of mass production but also in the field of medium- and small-scale production.

The decision by the enterprises concerning whether or not to "unmannize" depends first of all on an investigation of its economic impact. Take the mechanical manufacturing process, for example. The most practical method today consists of a manned process during the daytime and an unmanned process at night. Various preparatory work, such as making NC tapes, supplying workpieces, and tooling, are carried out during the daytime by human labor, while the actual work related to manufacturing is carried out by unmanned machines day and night. The proportion of personnel expenditures with respect to the total manufacturing cost, although it may vary somewhat according to the size and equipment of the factory and the type of product, is said to be approximately 70-80 percent in general for a medium-scale, general purpose manufacturing factory. Therefore, by simply adopting a three-shift operation consisting of a manned first shift and unmanned second and third shifts, 66 percent of personnel expenditures can be saved. This saving is usually large enough to balance the investment in equipment for unmannization. This is the other profile of Japan where unmannization thrives because of inflated personnel expenditures.

Significant Saving in Manufacturing Costs and Personnel Expenditures

The trend for adopting an unmanned operation format is found more often in the field of mass production, such as automobile production lines and rolling lines. These processes are readily adaptable to automation because the nature of such operations is fixed in pattern; thus, the so-called hard automation has been widely used in these applications. In recent years, however, it has become necessary even for a mass-produced object, such as the automobile to have a large number of variations in style in order to satisfy users' tastes and to make frequent model changes.

As a result, even a hard automation system must possess a certain degree of flexibility in order to be able to make changes to meet the needs of manufacturing plans. The conventional transfer lines used to be completely hard systems. These lines have since been made somewhat flexible through introduction of NC functions. These NC functions, or the order of the manufacturing process, are made easily changeable through manual or program controls. This type of flexible transfer line was put into operation last year by the Ford Motor Company for the manufacture of transmission axles, while General Motors is making plans to introduce it in the near future.

An unmanned production capability that is flexible was originally the requirement of medium- and small-scale production systems rather than mass production systems. From 50 to 70 percent of the machine parts manufactured in the world today are produced through medium- or small-scale production, ranging from several tens to several thousands of pieces and costing from several to several tens of times more to manufacture than the cost of mass production as shown in Figure 1. How to achieve reductions in the cost of medium- and small-scale production remains an unsolved problem for many advanced nations. One of the ways to solve this problem is to lower personnel expenditures by means of unmannization and, at the same time, to achieve production of a number of different items from a single production system--in other words, to realize an unmanned production system with flexible production capabilities. However, it is meaningless to attempt to manufacture completely different goods on the same production system. Similar parts must be grouped and manufactured together, using group technology, so that many jigs and tools and the NC programs may be shared and a reduction in operational cost may be achieved. Production systems having the capabilities described above are commonly called FMS (flexible manufacturing systems).

Adaptation of Automatic Tool Change Capability

In order to impart functional flexibility to the production system, it becomes necessary to contemplate the adaptation of ATC (automatic tool change) in addition to the use of NC mechanical parts. At the same time, the system must be combined with other machines having various functions in order to expand the range of the capacity and capability of the entire system. However, if the machines that make up the system are independent of one another, sufficient flexibility will not be achieved. It is essential that each NC function be computer-controlled centrally on the software side, and that each machine be connected with the other machines through an automatic workpiece transportation capability. Then, and only then, can changes in the product to be manufactured cope with changes in the NC program, the tools, and the process. Figure 2 shows a schematic diagram of the structure of an unmanned FMS, which may be classified according to its production capacity level as follows:

Level I: Machine processing
Level II: Level I + Washing and measuring
Level III: Level II + Assembly
Level IV: Level III + Material processing
Level V: Level IV + Special processing
Level VI: Level V + Product performance inspection.

Important Role of Robots

The majority of FMS's in operation today here as well as abroad belong to Level I, with some at Level II, but none of them is completely unmanned. The objects processed can be divided roughly into two groups: circular and noncircular. For processing circular objects, the NC lathe and robot are necessarily the core of the system. Company F started with automatic processing of DC motor parts and very few workers; today they are developing a new unmanned factory, relying on the experiences and results obtained over the past 10 years.

At the Tokyo trade fair held some time ago, a large number of NC lathes with robots were on display. These lathes caught the attention of many persons, [who saw them] as possible FMS components for the processing of circular objects, or as small production-processing cells for machining circular objects. With the processing of small parts as their principal object, these lathes are equipped with relatively small, simple robots. With these machines, a limited degree of unmannization can be achieved, involving manned daytime operation and unmanned nighttime operation at a relatively low cost. A similar FMS is being developed in Norway. We can get a glimpse of Norway's desire to establish high-level manufacturing technology in a sparsely populated area. In the Chicago show held last year, a "sighted" robot capable of recognizing objects with an infrared ray and having five-degree-of-freedom movement and fluid movement was put on display by Miracron Company and enjoyed great popularity. In spite of this, in the United States, where labor wages have risen threefold to fivefold in the past decade, the application of robots remains at only a 30-percent level. This seems to indicate that robot utilization is strongly based on the economy, so the use of sophisticated and expensive robots at the production site is naturally limited.

The Ferguson Company of the United States has successfully manufactured four kinds of gears ranging in diameter from 3.5 to 7.5 inches using a single system, while Rhota FZ200 of East Germany has manufactured spur gears, with a module as big as 4, at the rate of 200,000 per year and an average of 40 per lot. Use of the FMS in the manufacture of gears is vividly illustrated by these two example. In both of these examples, the system consists of an NC chuck lathe, a hobbing machine, and a shaping machine joined together by robots. In the case of East Germany, productivity is said to have increased 300-500 percent, while personnel expenditures have decreased 70-80 percent and floorspace requirements have been cut in half.

Examples of FMS's used for processing noncircular objects are greater in number than those used for processing circular objects. The most popular configuration is the DNC system, consisting of several machining centers with ATC and pallet changers linked together by some means of transport such as a conveyer or trolley. Machining centers handling large objects usually employ a column transfer format, while those handling smaller objects use a saddle transfer format. In Japan, manufacturing cells consisting of a machining center with an automatic pallet change attachment are gaining popularity. During the daytime the noncircular work pieces are set on the machines manually, while at night the machining operation is carried out automatically. Many examples of systems using this configuration were on display at the Tokyo Trade Fair. Most of the FMS's used for processing of noncircular objects in Japan today have small component parts and are designed to process only small objects such as cylinder blocks for small diesel engines, parts for marine engines, servomotor parts, and transmission cases. With assistance from the Mechanical System Promotion Association, Company T has developed and put into operation an FMS capable of automatically manufacturing more than 2,000 kinds of tool parts. Both the variety of manufactured parts and the precision of the work are said to have been raised by an order of magnitude. An FMS capable of achieving high precision of the order of a micron is a future goal. The FMS referred to above has taken the initiative.

In the United States, this type of FMS was first developed by the Miracron Company in 1968 under the name of "Variable Mission" and was put into application in earnest since 1975. Systems which are capable of processing several different kinds of parts such as transmissions, frames, and housing for tractors on a single line, or of processing more than two kinds of aviation engine crankcases, are gaining wide application and yielding good results in the field of farm machinery and aircraft manufacture. These two examples belong to the medium-scale production of a variety of products with high added value. These FMS's are thus contributing significantly to U.S. heavy industrial exports. These FMS's are huge systems having dimensions measured in several meters and handling work also measured in meters. These systems are characterized by a combination between a machining center and an NC multispindle machine in order to raise the efficiency of machining holes. On the other hand, such a combination tends to degrade flexibility by restricting the positioning of the holes. In order to overcome this shortcoming, some FMS's with head change capability have appeared. There are several tens of different multispindle heads which can be automatically changed by ATC.

In the EMO show held in Europe the year before last, the results of efforts by many manufacturers could be seen in the FMS's on display. In East Germany, a system known by the name of Plisma II has been in operation for 8 years. It is capable of processing 12 kinds of items including the table, saddle, bed, and columns of a milling machine. In West Germany and Italy, FMS's similar to those popular in Japan are in operation. For example, since last spring the Volkswagen Company has been manufacturing rear axle housing and gear boxes using FMS, while the Fiat Company is making six kinds of cylinder blocks by a single system. Good results are also reported by aircraft manufacturers such as Fokker, MBB, and Innocenti.

FMS is often considered the decisive factor for medium- and small-scale production. However, as illustrated by these examples, FMS represents a production line having a capability for manufacturing several similar parts. As such, the system has a layout which is suitable for the production of a certain fixed number of specific parts, so that it is by no means a universal system. FMS's which meet original needs for manufacturing similar parts began to appear in Japan very recently. These FMS's consist mainly of various NC process machines already purchased and individually converted into DNC machines and linked together by the existing transport system. Such honest steps and detailed investigation are indispensable for the development and operation of FMS's. In this sense, a close contact between machine tool manufacturers and users is of utmost importance. We have much to learn from the powerful U.S. manufacturers, who have established production systems departments to achieve this goal.

It is unclear exactly how many sets of FMS are in operation today in the world, due to a lack of statistics and also to the fact that the definition of FMS varies from country to country and from person to person. To give approximate figures, there are 30 in Japan, 20 in the United States, 15 in West Germany, and 10 in the other European countries. It has been only several years since FMS was first adopted in earnest, but much can be expected of its future development.

Integrated Software Development

In order to achieve the ultimate goal of true unmanned operation, the reliability of the system must be basically improved. To achieve this goal, what is needed most urgently today is to develop and establish various necessary technologies, in addition to those basic functions illustrated in Figure 2, such as automatic tool management capability (control of tool life; prediction and detection of tool damage), automatic correction of manufacturing errors, and prediction and detection of operational abnormalities. Research activities related to these topics are being carried out vigorously today.

Many of the systems in operation today usually reduce their production rate to 70-80 percent of the norm during the unmanned operation at night in order to avoid any accident that may occur. Development of an integrated software system is indispensable for the operation of an unmanned system. Since 1977, the U.S. Air Force has been carrying out an ICAM (Integrated Computer Aided Manufacturing) project with a total budget of 100 million dollars over an 8-year period. Japan has fallen somewhat behind in effort in this area. In order to make up for its late start, England has launched its ASP (Automatic Small Production) Plan, but it is still in the paper planning stage. There are several projects going on in West Germany, but no large-scale integrated program as yet. In this regard, a large-scale project entitled "Ultrahigh Performance Complex Production System Using Laser Technology" undertaken by Japan's Industry and Technology Office under the Ministry of International Trade and Industry, with a total budget of 13 billion yen, will attempt to develop a system that will be able to handle every stage of work, from raw materials to finished product. The fruit of this effort is expected to have a great impact on high added value medium- and small-scale production.

First of all, the greatest concern of users is the size of robot. If it is too big, it will take up too much floorspace and the users may not be able to introduce it even if they want to because of space limitations. When robots are introduced into the assembly lines, their size must not be so large as to induce fear in the humans working in the vicinity. This consideration is said to be very important from the viewpoint of labor safety.

The Unimation Company in the United States has attracted attention by developing a robot the size of a human arm. Their "Puma 250," which is said to be shaped like the upper half of the human body, has an upper arm and a lower arm approximately 20 cm each. It has six degrees of freedom, a position-fixing accuracy of $\pm$ 0.05 mm, and can carry a maximum weight of 1.5 kg. It is said to be suitable for assembling electrical products. The Unimation Company is at the stage of observing user reaction by presenting this compact robot at an exhibition, but there is no doubt that it will be on the market sooner or later.

In Japan, a Model-0 robot for machine tool application nicknamed "Semi Robot" has been developed by the Fuji Trading Company, which has taken the initiative in miniaturization. It is a tiny robot approximately 1 meter long and weighing 110 kg. It does not take up much space and can be attached directly to the machine tool. It is capable of handling work from its perch as if it were a "semi" [cicada] alighted in a tree; thus the nickname "Semi Robot."

In Europe--and especially in Italy, which is the target of a labor offensive--development of robots which can take the place of human workers is being aggressively pursued. The typical small robots developed in Europe include Pragma A-3000 developed by the DEA Company. This robot is of the rectangular coordinate type, having a total length of 1 meter and a weight of 35 kg. It was designed to handle small parts, and plans call for its sale and introduction into the Japanese market at this time.

The key links of miniaturization technology include the material and the servomechanism. In order to make a small robot which is capable of lifting heavy weights, a material having a small specific gravity must be used. To develop a small and powerful robot, every company concerned is engaged in the research and development of FRP (fiber-reinforced plastics) material and light metals. The servomechanism must be strong, with high speed and the capability of achieving high precision in positioning. Basic research in this area has just begun in earnest.

Another characteristic topic related to the development of industrial robots is the development of senses such as sight and other judgmental functions--in short, a "brain."

Conventional industrial robots, such as spot-welding robots and spray-painting robots, are taught by the human operator, who literally takes the "hands and feet" of the robot and teach every movement. Afterward, the robot performs work by repeating the movement faithfully. This type of robot is in possession of memory and a review capability, but it does not possess either sight or other judgmental powers. This type of robot is a real "hard worker" and will go through the same motions again and again as long as no trouble develops, but it completely lacks flexibility. It is completely incapable of changing its movement in response to changes in work conditions such as a misplaced workpiece.

Accuracy in positioning workpieces is not so critical for spot-welding and painting operations, so as long as the workpieces are positioned with a certain degree of accuracy, the work can be performed successfully by conventional robots. However, for work requiring a high degree of accuracy or deft fingers, the conventional robots described above fail to qualify. The movement in the direction of imparting senses such as sight and judgmental capabilities to robots originated from this need or desire to let industrial robots carry out a higher level of operations. Robots with senses and judgmental capability are being developed by many robot manufacturers today. These robots include arc-welding robots which are capable of following a certain weld line by a sensor, or its eye, and which can move the welding equipment forward without the need to be taught by the human operator for every different job. The opportunity for robot manufacturers to develop this type of robot is great today, because the needs for automation of operation are higher than ever.

One method uses a TV camera as the eye to track the welding line. Development of simpler methods of tracking is actively being pursued because of economic considerations. Each manufacturer is taxing his ingenuity to come up with a new design using various sensors such as magnetic sensors and contact sensors. Each manufacturer is trying very hard to produce cheaper and more versatile robots, while taking care not to infringe upon other manufacturers' patent rights.

There also are robots with a sense of touch. An example of this type of robot is the grinder robot developed by the Sumitomo Heavy Machinery Industry for grinding metal molds as a finishing process. The tool--i.e., the grinder--senses the force from the object and automatically makes an adjustment of the force applied on the grinder in order to obtain a smooth finish on the metal mold. This grinder robot is said to have been developed specifically for a certain manufacturer for the purpose of finishing metal molds. It is said to have contributed significantly to the automation of the operation.

Another example of a robot with a sense of touch is the so-called material-handling robot, which is capable of picking up and putting down materials and tools. The touch sensor consists mainly of micro-switches, strain gages, pressure-sensitive conductive rubber, and semiconductor elements. Other forms of sensors also are being developed.

There also are robots in possession of well-developed "eyes" and judgmental functions together with a simple actuator. This type of robot is capable of carrying out visual inspection of the products. The work is first of all captured by a television camera; the picture image is then decomposed into image elements by a computer, and the characteristics of the object are recognized by the pattern recognition technology. Abnormalities in shape and size are thus detected. This type of robot is being used to eliminate defective pills and capsules in the pharmaceutical industry, and also in the field of agriculture in grading vegetables and fruit such as tomatoes and melons.

In addition, there are other types of robots capable of inspecting labels on bottles, checking defective packages such as tobacco cases, checking bad printing, and even sorting fish which are transported by a conveyor belt. The robot memorizes the different features of various types of fish. Human judgmental power is no doubt superior to that of the robot as far as visual inspection is concerned; however, human judgment can be affected by and fluctuate according to his mood, fatigue, and individual differences. That is why this type of robot is fast gaining popularity.

A type of robot that is technically very difficult to make is a robot to do assembly work. Since this type of robot is in great demand, robot manufacturers are accelerating their development activities. One kind of assembly robot that exists today is engaged in the assembly of motor shaft bearings. Generally speaking, to be able to put two machine parts together, a high degree of accuracy in matching positions is required. This requirement complicates the control of the robot's hands. Many attempts have been made in the past to perfect this technology, but we have been groping in the dark so far.

However, with further improvement in various computer capabilities and in pattern recognition technology, together with innovations in mechanisms that solve problems related to deft fingers, we are coming ever closer to the day when we can realize this type of robot.

For example, in the transition from the position control format employed in the conventional industrial robot to the "force control format" and robot with soft fingers introduced in the United States, the mechanisms and structures suitable for assembly robots are being developed. Based on these technological advances, the Hitachi Manufacturing Company has developed and publicized a robot system capable of assembling a sweeper and a toy automobile. Use of assembly robots to install automobile tires has already begun in part of the industry. More and more assembly robots will enter into industrial production as the technology is further improved.

In addition to these applications described above, robots with "eyes" and judgmental powers are being used in areas where human operators cannot approach, such as inside an operating nuclear power generating station. This type of robot can be used to investigate the inside of the nuclear power generator in case of an accident. This type of robot is capable of going up and down steps on its endless track and, in addition to being able to see with its TV camera, it is capable of performing simple work such as opening or closing valves by means of remote control. Development of this type of robot has already begun, under the sponsorship of the Ministry of International Trade and Industry, and the project is to be finished in 5 years. With the development of this type of robot technology, it is the understanding of those concerned that maintenance of machinery and factories by robots can be realized in the future.

There is also a trend in which the field of activities of robots is to be broadened by imparting to them the faculty of movement. The most well-developed robot of this kind is one which works under extreme conditions that are unbearable for a human operator. In addition to the surveillance robot used inside the nuclear power generator in the field of energy generation, a large sum of development capital has been invested in robots that will be capable of operating oil-drilling rigs on the continental shelf.

The lower half of the body structure of robots can be divided roughly into two types: those with many legs and those with no legs. Multiple-legged robots, like insects, have many legs so that they can maintain their balance on uneven ground. A typical example of this type of robot is the eight-legged robot developed by the Komatsu plant to be used for underwater operation. Using four of its eight legs, it first stabilizes itself, then, using the other four legs, it can step forward like an inchworm. It can move forward by this method a distance of approximately 200 meters in an hour over uneven terrain that has a maximum unevenness of 2 meters. This robot is taking an active part in the construction of a bridge connecting Honshu and Shikoku at the construction site. The same company is undertaking another project to develop a robot which will be used in the development of the continental shelf at a depth of 500 meters and on soft ground.

A six-legged robot resembling an insect was first introduced by the Mechanical Technology Institute of the Industry and Technology Department. The best-known four-legged robot is the "PV II" developed by the Umeya Research Laboratory of Tokyo Industrial University. The legs have joints, and the robot propels itself by moving its legs alternately. It is capable of climbing up and down stairs and also can change direction. One of the interesting features of this robot is the fact that it is the first robot with a (pantomec) leg structure--which is a three-dimensional application of a pantograph. A 3-year research project is being carried out in which an intelligent robot that is capable of avoiding obstacles and ditches is to be developed.

The Umeya Research Laboratory of Tokyo Industrial University is also undertaking the development of a legless snake robot. This robot consists of many sections joined together. It is capable not only of swinging its head left and right but also of raising its head and going over obstacles in its way. The advantage of this type of robot is its slender body, enabling it to enter small holes or operate in a narrow space. It is expected to display its full power in the field of nuclear power generation and the petrochemical industry, where a large number of pipes and steps are involved.

Two-legged robots resembling the human body are being developed for artificial legs. Refined innovation is required to solve problems related to shifting the center of gravity, and their cost is bound to be very high. At present there is no prospect for industrial application.

As for the capability of movement, the movement of the work object in addition to the movement of the robot can also be contemplated. The concept of the flexible manufacturing system (FMS) has thus entered the production line. In its production line of passenger cars, the Fiat Company of Italy has developed a robot gate system consisting of a multiple number of gates with built-in spot-welding robots. The body to be welded on a carrier is dispatched to the empty gate one after another by a controlling computer. The system is said to have achieved great results. The decision concerning whether the robots or the works ought to be moved should be determined from the circumstances at the site, with consideration for the cost.

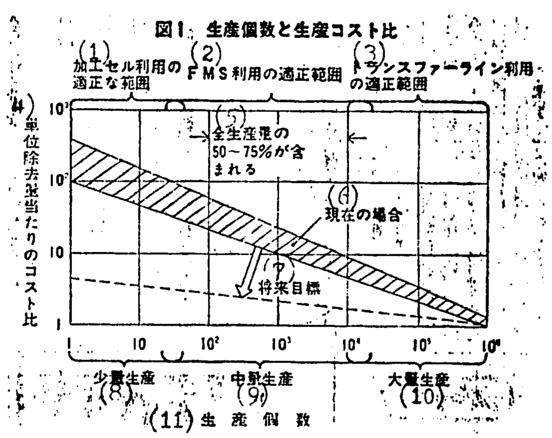


Figure 1 Quantity of production and production cost

KEY:
(1) Range suitable for utilization of processing cell
(2) Range suitable for utilization of FMS
(3) Range suitable for utilization of transfer line
(4) Unit cost
(5) Containing 50-75 percent of total production
(6) Present status
(7) Future target
(8) Small-scale production
(9) Medium-scale production
(10) Mass production
(11) Quantity of production

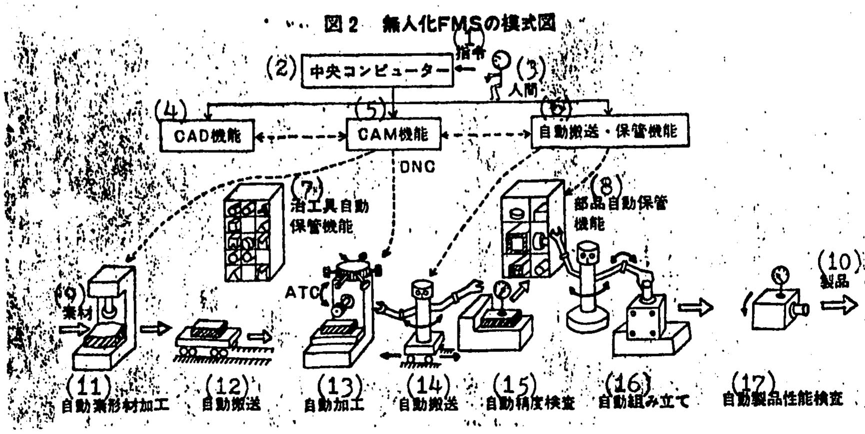
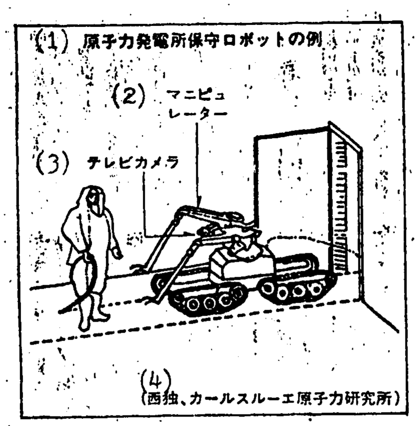


Figure 2 Schematic diagram of unmanned FMS

KEY:
(1) Command
(2) Central computer
(3) Human operator
(4) CAD function
(5) CAM function
(6) Automatic transport/storage function
(7) Automatic tool custody function
(8) Automatic parts custody function
(9) Raw material
(10) Finished work
(11) Automatic processing of raw material
(12) Automatic transport
(13) Automatic processing
(14) Automatic tra: :port
(15) Automatic accura:y in: ection
(16) Automatic assembly
(17) Automatic performance inspection for finished work



KEY:
(1) An example of maintenance robot for nuclear power station
(2) Manipulator
(3) TV camera
(4) Karlsruhe Nuclear Energy Institute, West Germany

[Article by Kitaro Yoshida, Chief of Machine Tool Section, Mechanical Department, Mechanical Technology Institute, Academy of Industry and Technology]

There are a large number of factories manufacturing a variety of products at small to medium volume in Japan, and these factories constitute the mainstay of Japan's industry. When automation was attempted in order to promote industrial production, the problem encountered was the automation of assembly work. Mechanical processing can be automated to a large extent by use of NC machine tools, but automation of assembly work has been successful only in a small number of flow lines. Automation of the assembly work at an ordinary machine shop is considered to be the most difficult task.

The assembly work at an ordinary machine shop involves adjustment work such as fitting and positioning, and the most complicated assembly work must be done by the human hand. These are the factors which make automation difficult, and this is the state of affairs today. However, the product can be redesigned so that complicated assembly work such as positioning and fitting may be eliminated as much as possible. This is the basic concept of complexing.

Complexing means integration of processing and assembly. All operations related to processing and assembly are classified, and those assembly operations that can be done or are more conveniently done during processing are done immediately, disregarding the conventional order of processing preceding assembly. These operations are carried out as far as possible with a single set of machines (called a cell). The operational format of the entire plant consists of independent processing and assembly cells plus a complex work area. This type of production system is called a complex production system.

Development of a complex production system for the processing of raw materials was started in 1977 together with laser processing technology. With an investment of 13 billion yen over a period of 7 years till 1983, the project is to complete the system design of a complex production system and to construct an experimental plant to verify the feasibility of the complex production format. Combined processing and assembly operations especially designed for the purpose of verifying the concept of complexing will be tried out in the experimental plant.

In conducting the system design of the complex production system, the project started out with elemental research, including automatic design technology, process design, and process management technology needed by the plant operation, then moved on to the concept of modular machines capable of handling a large variety of products with diversified processing and assembly work. Development of elemental technologies, such as the design of modular component machinery, structural analysis, treatment capability, and universal fixture and development of the mechanisms especially for automation of assembly machines, is being systematically carried out. Automatic inspection and diagnosis technology consisting of a system to measure the motion of the processing machines, a system to ensure mechanical precision, a system to inspect the finished product, raw material treatment technology for the development of four types of processing machines, and laser technology needed for the construction of a 20-kW laser transmitter are to be developed next. A medium-output power laser will be used in the experimental plant.

These elemental research activities will, except for a small portion, all be completed by 1980. Starting in 1981, the design of a complex production system and the design of an experimental plant will be undertaken. The results of the elemental research are to be incorporated into these designs. The elemental development which will be incorporated into the system with processing and assembly operation cells as its center will be described briefly next.

The machining-assembly subsystem constitutes the core of this project. The subsystem is expected to possess the following capabilities: be able to cope swiftly and flexibly with a large variety of production situations; be able to reduce the processing-assembly steps to 60 percent; and be able to achieve fitting of the IT6 class. At the same time, all treatments carried out at the site (inside the processing cell) are to be automated. In order to solve this problem, the following actions were taken: (1) A highly flexible modular construction and machine tools with unit change format were adopted (Figure 1). (2) The main spindle was made compact and multifunctional (turning and milling can be done with a single head unit). (3) A feed mechanism which can be easily engaged as well as disengaged was used to match the changeable modular unit. (4) A scrap treatment technique was developed to cope with automation. (5) A universal attachment tool capable of handling variable work objects with flexibility was adopted. This system adopted a method of attaching a chuck to all work objects in order to facilitate removal of chips. The direct feed method was employed to transfer work objects from chuck to chuck. A simple fitting operation was also carried out. (6) Each unit was to have its own control and drive mechanism so that its operation could be independent of the other units. (7) A technology was developed to predict troubles and maintain precision by means of continuously monitoring and diagnosing the operational conditions of the entire system in order to operate the system at maximum capacity at maximum efficiency.

The automatic assembly machine and the processing machine will occupy an important part of the system. During the course of development, emphasis was made on the following points: (1) All assembly work was to be carried out in one place. (2) The system was to consist of changeable modular units. (3) Assembly tools with flexibility were to be used. (4) The assembly machine was to possess a partial processing capability.

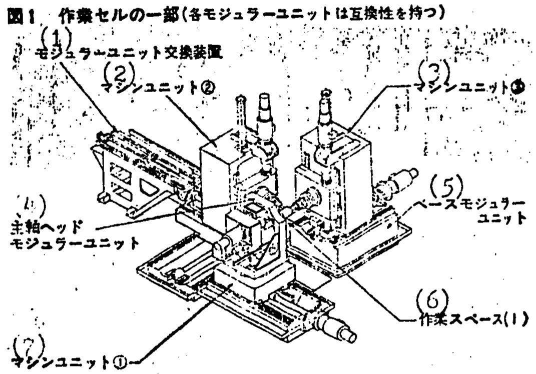
The finished products after assembly (the functional parts) will be inspected and the results of the measurements will be fed back to the assembly line in order to minimize the number of defective parts. In order to accomplish this, research efforts on the following subjects are being carried out: (1) Product performance inspection data are compiled in order to ensure product quality. (2) Operational performance of the functional parts are inspected. (3) The dimensions, shapes, shaft deflection, accuracy of rotation, and torque are to be inspected by a device consisting of modular components.

In order to introduce laser equipment into the processing and assembly operations, medium-output power laser equipment is being developed now. Based on the results of this activity and the experience gained from it, large-output power laser equipment of 20 kW rating is to be developed in the future. Development of precision component parts required by the laser equipment is being carried out today.

Management and diagnostic systems in support of the complex production system are also being developed. Since the processing and assembly system has a layered structure, the plant management system also incorporates this type of structure, and the overall system management consists of layered unit management. Development of these elemental technologies is expected to be completed by 1980, and then the design of the complex production system itself will begin.

Although the basic conceptual design of the complex production system which constitutes the ultimate output of this project was carried out at the very beginning, many improvements and various new ideas have been added to it since then with the progress of various research activities. For example, the concept of complexing was introduced together with the utilization of compact production cells in which both processing and assembly operations are to be carried out, while the basic research related to the format of quantitative evaluation of the system design and preparation of the algorithm of complex engineering plans have been kept up and, at the experimental plant, the complex production format of combined processing and assembly operations, which constitutes the core of the complex production system, has been verified. Some of the hardware employed in the com. lex production system which are under study at the experimental plant today include the method of changing the head unit on the main spindle of the processing unit, the method of multiple spindle processing using chucks, the method of a conveyerless production process within each cell by means of the direct feeding of workpieces, implementation of such assembly functions as fitting and welding, and the capability to carry out measurements at high speed. Figure 2 shows an imaginative system layout containing various essential components expounded above. Based on a careful assessment of this, further improvements to the system will be attempted: for example, further simplification of the assembly work; execution of simple processing work, using the hardware normally used for assembly work if necessary; and a more basic, organic reorganization of the production process in order to reduce the number of processes and steps. This complex production system may be subdivided and used partially according to need. Therefore, the study of this complex production system is expected to provide helpful guidance for further improvements in productivity as well as automation of mechanical processing plants in the future.

図1 作業セルの一部(各モジュラーユニットは互換性を持つ)



(8) (日経メカニカル1980.10.27から)

Figure 1 A portion of the processing cell (each modular unit is interchangeable)

KEY: (1) Modular unit changing facility
(2) Machine unit 2
(3) Machine unit 3
(4) Main spindle head modular unit
(5) Base modular unit
(6) Workspace
(7) Machine unit 1
(8) (From NIKKEI MECHANICAL, 27 Oct 80)

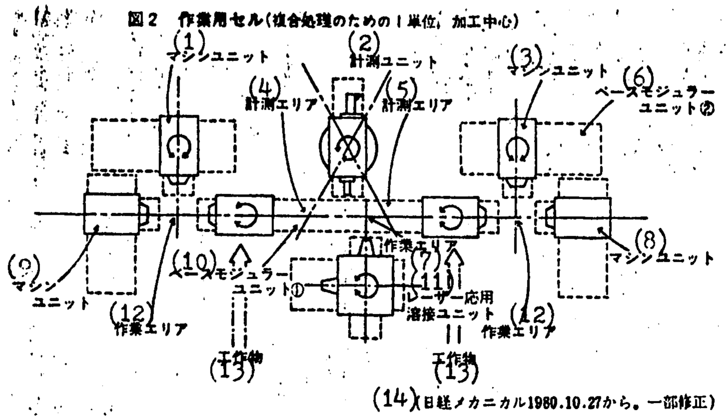


Figure 2 Processing cell (processing center, one unit of complex production system)

KEY:
(1) Machine unit
(2) Measurement unit
(3) Machine unit
(4) Measurement area
(5) Measurement area
(6) Base modular unit 2
(7) Work area
(8) Machine unit
(9) Machine unit
(10) Base modular unit 1
(11) Welding unit utilizing laser
(12) Work area
(13) Work object
(14) (From NIKKEI MECHANICAL, 27 Oct 80, partially modified)

[Article by Tatsuji Wada, Director, Toyota Machine Tool Division]

There are many different types of the so-called unmanned factory, or FMS, according to the types of industry and the production format. One must take note of the fact that, regardless of its size, each system constitutes either a production field or a factory. In the metal-mold manufacturing industry in particular, where there has been a growing interest in the adoption of NC operations in recent years, the general trend is not so much toward large factories but rather strongly toward a functional center type of factory. The FMS referred to here consists sometimes of one machine which is guided by some software, and the system is investigated and equipped and treated as though it is a factory. Generally speaking, however, an FMS is a production system consisting of a group of from several to several tens of machine tools.

Coping With Type and Quantity of Production Object

The fact that the base machines of an FMS consist mainly of NC machines speaks loudly of the utilization of the inherent flexibility of the NC machine. The most commonly used NC machines are, in general, manufactured not so much for any specific purpose but rather for a general application. One of the important points for investigation and discussion during the process of designing a processing line is to find out whether a given machine is suitable for the processing of the parts involved in the type of industry.

In other words, based on the work object of the FMS, the work process required by each individual work object and the knowhow required by each process must be carefully taken into consideration. The processing line must be constructed from a proper combination of various machines necessary for the execution of the required treatment.

However, one thing that must be kept in mind during the process of designing a process line is the fact that what can be carried out safely by the NC machine is only a portion of the entire work process, and that other portions of the work process must be done by other means. In fact, production efficiency is affected more significantly by this portion of the work process.

With this as a background, a number of FMS's have been developed mainly for the purpose of processing noncircular and circular work objects and put into actual operation. Although there is no fixed format for classification of FMS, the fundamental items that must be considered include the type and the quantity of the work object.

One FMS is a somewhat specialized FMS for the treatment of several types of similar parts. In this case, the main objective is mass production of a product having uniformly good quality. Since the work objective is clearly defined in this case, construction of the production line also has a clearly defined guideline.

The mechanical elements that are required for mechanical processing include machines, cutters, fixtures, and the work data. These elements are by nature changeable according to the work object. As a result, a process line with high-performance characteristics can be constructed. This type of process will be significantly affected by the work object, so that it appears that a process line with a somewhat specialized purpose will be easier to organize.

One of the special machine tools which appears to meet these needs is the machining center with changeable head. In contrast to an ordinary NC machine having only one cutting tool, this machining center consists of an NC machine possessing from several to several tens of cutting tools attached to a multiple number of special head units which can be changed automatically. Its production efficiency is said to be quite distinguished.

At this juncture, special attention must be paid to the following. Cutting tools used by these machines are usually standard tools, but the head units must be specially made so that the production plan as well as any plan alterations can be well managed.

In addition, other types of NC complex machines have also been manufactured for some special purposes or effects, such as a special NC machine for boring and facing, a dual-head NC milling machine, and NC complex machinery for machining and drilling.

Consideration of Standardization in Construction of Processing Line

Besides the special-purpose FMS's described above, there are many FMS's for mass production of small, high-precision parts.

The most important consideration related to the design of a processing line is the line balance--namely, how every machine on the line may be operated with the highest efficiency. Most NC machines manufactured for use on the processing line are all-purpose machines with a finite number of cutting tools. Therefore, the gap between the finite number of cutting tools and the number of cutting tools that are required for the production of a variety of work objects constitutes the most important bottleneck.

However, if every part is scrutinized carefully, one will probably discover that there are ways to get around this bottleneck. That is to say, in the development of a part, from design through the manufacturing process, various measures for production management must be standardized and also "GT-ized." The supporting technologies to achieve line balance, such as transportation technology, scheduling technology, and software technology, will definitely play very important roles.

Regardless of format, FMS is moving toward application of sensor technology in order to achieve uniformly high-quality products.

The role of sensors is to ensure the accuracy of the product and, at the same time, to achieve stability of the FMS itself. When an unmanned production system encounters a situation which requires human hands, it must be able to respond quickly to the situation or, if possible, automatically rectify the situation and continue production. To be able to do this, it must be in possession of a means of continuously checking every machine in the system. For example, the conditions of cutting tools (sharpness, damage) and changes in machine position (position change in main spindle and screw) must be monitored continuously.

Establishment of Important Software

The technology needed to further raise the standard of FMS in the future is nothing other than the systems technology which groups together various technologies related to precision shaping of raw materials, measurements, tooling, transportation, maintenance, and surveillance. Furthermore, when the system is being planned--in the so-called design stage--various hardware and software items must be able to be chosen arbitrarily from a "menu" to suit the needs of the work objective. Establishment of such a hardware-software structure is highly desirable.

In other words, the idea of modular structure has begun to permeate the entire spectrum of functions necessary for the construction of FMS. Important and urgent themes for immediate attention include those weak spots today such as detection of cutting tool life and regrinding of cutting tools, automatic setting and determination of supply routes, automatic loading and unloading operations, automatic diagnosis and repair, solution of problems related to the removal of chips and coolant from the angle of structural design and system construction, and more extensive use of robots. When all these items become reality, one after another, a brandnew FMS which is quite different from the FMS of today will be born.

The one technology which is the foundation to all these technologies is software technology. Growth of this technology will have a profound effect on the development of the entire system. Cultivation of software technologists well versed in mechanical processing knowhow is a time-consuming process. A glimpse of the gap between FMS today and the image of FMS tomorrow can be caught here.

At any rate, progress can be made step by step if we question and investigate the human operation in the production system today in minute detail.

At the end of this long journey, we wish to find a satisfactory FMS of high standard, or the ultimate unmanned factory.

[Article by Masahiko Tajima, Head of Sales Department, Materials Circulation Department, Murata Machinery Industry]

It has been more than 10 years since the appearance of unmanned factories, and the subject has passed the stage of mere academic discussion and become a topic on the practical application level. The transfer line, which has already been perfected for the mass production of a small number of parts, is one of the best examples of unmanned factory facilities. Although the transfer line is known for excellent productivity, it lacks the flexibility of a system capable of coping with the changing demands of customers in changing times.

On the other hand, a variety of NC machine tools and machining centers with excellent flexibility and reliability have appeared as a result of progress in electronics technology. These, in combination with CAD and CAM systems which were developed in time, have brought the equipment needed for unit construction to an almost complete level. However, there are still many other problems that need to be solved before these machines, which though highly functional are still very expensive, can be economically adopted into a production system with sufficient guarantee that the investment risk will be covered.

With the expanded application of computer technology and the ripening of research and development efforts by advanced technological groups and industries in recent years, unmanned factories have become a reality. We have seen them developed into pilot plants and practical application systems.

Some of the necessary conditions of the unmanned factory system include the very high reliability of its component machinery and, at the same time, the fact that the system itself must be able to cope with future expansion and reorganization both technologically and economically. Various components of the system--including automatic processing machines, assembly machine equipment, transport equipment such as conveyors and unmanned vehicles, automatic warehouses in custody of materials, tools, and workpieces, computer systems which control the movement of these components, and sensors to gather information--all these must have reached the same level of technological standards if the system is to function properly.

However, among all of the components mentioned above, development of the transport system has lagged behind quite significantly. The delay has been caused not so much by the reliability of each individual transport equipment represented by conveyors and unmanned vehicles, but rather by the complexity of the transport format that exists within the system. The difficulty lies in the development of universal equipment capable of coping with infinitely variable conditions in the field, such as the shape and weight of the workpieces to be transported, the route, the timing of supplies, and the loading and unloading format.

The examples introduced herein illustrate the use of an unmanned vehicle system having a number of brandnew functions as the key measure in the construction of an unmanned factory. This is a feat heretofore considered unattainable--namely, a direct link between the production process and the transport process. This transport system is capable of coping with a number of changes that may take place in transport conditions, such as insertion of a workpiece into a production process and recovery of rejected workpiece. The system has been put into actual operation.

Example A. Assembly, Inspection, and Test Run Lines for Tractor Transmission (Figure 1) (using three 1-ton-capacity unmanned vehicles with a total travel distance of 300 meters)

According to the production plan, the kit parts marshaled at the exit of an automatic warehouse are supplied to assembly lines I and II. Partially assembled parts are transported from assembly line I to assembly line II, where the assembly is completed. Completely assembled parts are then transported to the inspection line, and those parts which pass inspection are then coupled with an engine in order to carry out a test run. Those parts which are rejected are returned to either assembly line I or assembly line II for correction. All transportation work is carried out by three unmanned vehicles whose movement and information related to the work process are controlled by a process computer.

Example B. Machine Tool Parts Processing and Assembly Factory (Figure 2) (using three 1-ton-capacity unmanned vehicles with a total travel distance of 2,300 meters)

These unmanned vehicles are used to supply raw materials to more than 50 NC, MC, and other types of machine tools, to transport workpieces between machine tools, to transport finished workpieces to the inspection line, and to transport workpieces which have passed the inspection to the automatic warehouse, where parts waiting to be assembled are kept.

At the assembly line, each assembly station will issue a delivery request to the automatic warehouse, which will then dispatch parts to the delivery station, from which the parts will be transported by the unmanned vehicle to the assembly station that requested them.

The three unmanned vehicles used here move around according to the changes in work volume of three shifts (24 hours) of process lines and one shift (8 hours) each of inspection lines and assembly lines. The movement of the unmanned vehicles, the information concerning completion of work and raw materials waiting to be processed, and stock management of the automatic warehouse are all processed by the process computer. This system is further characterized by the fact that the three unmanned vehicles are directly connected to the loading and unloading stations handling several different shapes of parts.

Example C. Passenger Car Body Assembly Line (Figure 3) (using four 1-ton-capacity unmanned vehicles with a total travel distance of 250 meters)

In response to a request issued by each assembly station, an unmanned vehicle delivers the requested parts from the automatic warehouse in a pallet as a single unit to the assembly station which requested them. A number of special pallets are used to accommodate parts of different shapes and sizes, such as doors, front panels, etc. These pallets of different sizes and shapes are all handled by the same unmanned vehicle.

Example D. Press Line (Figure 4) (using two 3-ton-capacity unmanned vehicles with a total travel distance of 220 meters)

The raw material (sheet metal) stored in the automatic warehouse is distributed to more than 10 stations housing shears, press brakes, punch presses, etc. Work parts are transported from one station to another, and finished parts are collected. All information concerning the movement of unmanned vehicles, process management, and management of stockpiles in the automatic warehouse are processed by microprocessor.

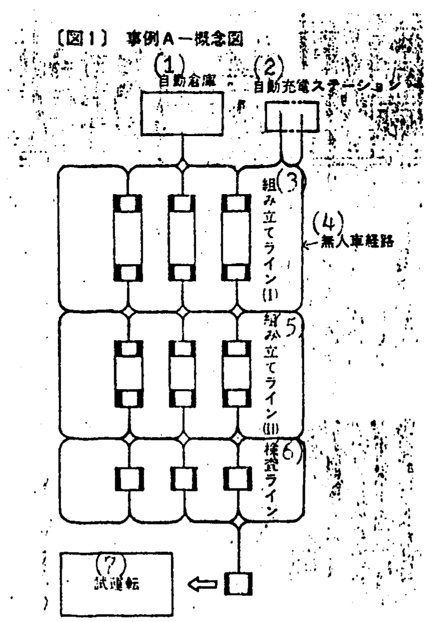


Figure 1 Example A - Conceptual diagram

KEY:
(1) Automatic warehouse
(2) Automatic charging station
(3) Assembly line 1
(4) Path of unmanned vehicle
(5) Assembly line 2
(6) Inspection line
(7) Test run

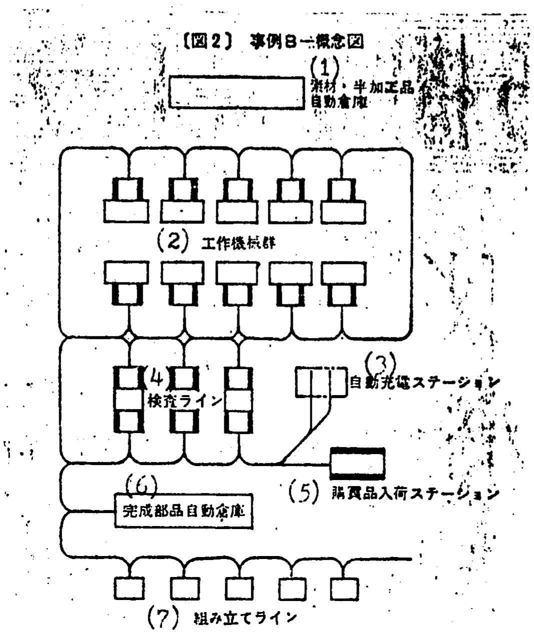


Figure 2 Example B - Conceptual diagram

KEY:
(1) Automatic warehouse for raw materials and semi-finished goods
(2) Machine tool group
(3) Automatic charging station
(4) Inspection line
(5) Receiving station for purchased goods
(6) Automatic warehouse for finished goods
(7) Assembly line

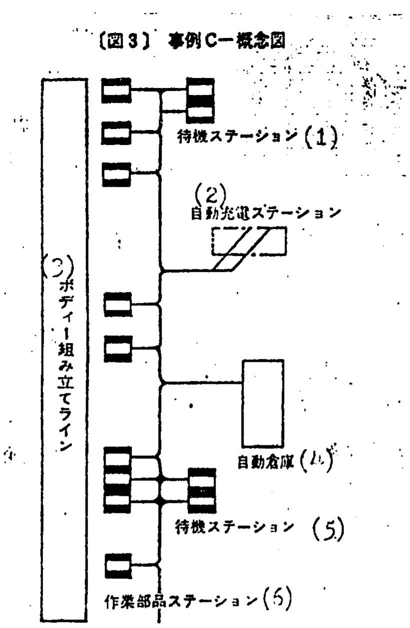


Figure 3 Example C - Conceptual diagram

KEY:
(1) Waiting station
(2) Automatic charging station
(3) Body assembly line
(4) Automatic warehouse
(5) Waiting station
(6) Work parts station

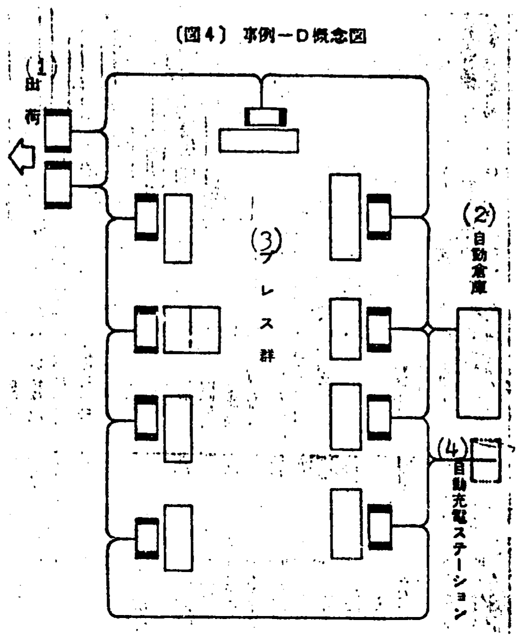


Figure 4 Example D - Conceptual diagram

KEY: (1) Shipment
(2) Automatic warehouse
(3) Press group
(4) Automatic charging station

[Article by Fumio Hashimoto, Professor of Engineering, Osaka Prefectural University]

The basic technologies involved in automation, which is also known by such expressions as mechanization or laborsaving device, include automatic operation, automatic control, and application of electronic computers.

Factory automation was started by the automobile industry. Today, automation is practiced by many other industries as well--for example, food processing factories, candy factories, film factories, pharmaceutical plants, the iron industry, and many others.

Automatic operation means that, without use of human hands, a certain object is automatically processed, assembled, or made to undergo a chemical reaction. Take a process involving machine tools, for example. A series of machine tools which operate automatically are arranged according to the order of the work process, and this series of machine tools is combined with a device which is capable of transporting the raw materials and semifinished goods so that a chain of operations can be carried out. There are two forms of operation. One form of operation is merely to mass-produce a certain product automatically. Another form of operation is called a feedback operation, whereby a product is examined to find out whether a set of predetermined conditions is satisfied. If any discrepancies are found, the signals are fed back to the machine and the machine makes the corrections automatically until all errors are corrected. Control of this feedback action is called automatic control; this constitutes the foundation of automation technology.

On the other hand, electronic computers which were used exclusively for scientific computation in the beginning have in recent years been finding applications in information processing. This field of application is growing bigger, in proportion with the technological advances. Computers are capable of recording and storing information for use in operating machinery in factories, in managing the businesses, and even in many social activities.

Now, then, what is the present status of automation technology in today's production plant, and what are the technologies that are in need of development today?

A completely automated factory is one which carries out its entire manufacturing process automatically--checking out the raw material or workpiece from the warehouse, processing it, and turning into finished product. This means that all basic operational processes such as machining, inspection, transport, and assembly, as well as the centralized control over these processes, must be done automatically. To these functions must be added a factory management capability: the capability to make production plans, issue work orders, and carry out the overall management of affairs; to make decisions concerning types and numbers of goods and set up a production schedule according to predicted demand; and to issue work orders to the manufacturing equipment to manufacture a certain type and number of parts by a certain date. After the automatic manufacturing operation is set into action, the progress of each operation must be constantly checked against the planned schedule and appropriate measures taken when discrepancies are detected.

Achievement of this kind of complete automation in both production and management is technologically feasible. However, it has not been realized today. Manufacturing technology has achieved quite extensive automation. In the machinery industry, machine tools have progressed from NC to DNC to CNC and even to AC (adaptation control). However, automation of machine assembly has been only partially successful. Various parts-handling operations required in any assembly process, such as arranging, transferring, positioning, inserting, and putting together, have not been completely automated yet.

The automation technology in need of development today is the automation of human faculties, such as the ability to gather information and to make judgments. Among many human faculties, the sense of sight is being automated by use of TV camera, by which the shape and arrangement of objects are recognized and the position and orientation of objects are determined. The sense of touch, which detects contact, pressure, slip, and proximity, among other things, can be simulated by various sensors capable of detecting these situations. Further development of this type of sensor is urgently desired. Generally speaking, the information to be detected is nonelectric. This information cannot be fed directly into such information processing devices as micons. Therefore, the information must be detected and then turned into an electrical signal immediately, so that the data may be processed by the computer.

There is a great variety of sensors. These sensors must be skillfully combined so that the circumstances of production process may be truthfully captured and the production process properly controlled. In other words, a function that is indispensable for the assembly process and the inspection process is the capability to process various signals coming from various sensors, to interprete commands, to set up sequences, and to take proper action in response to the environmental stimuli. There are still many unsolved problems related to manipulators when compared with human beings--for example, the arrangement of joints in the manipulator, the determination of various link elements, dynamic analysis of multijoint linkage, the development of algorithms for computer control and application technology of machine system, just to name a few.

In addition, state surveillance technology for preventive, positive maintenance is also indispensable for factory automation. Surveillance technology includes sensor technology in relation to microcomputers, system technology which captures the entire production activity of the production system, abnormality forecast technology, diagnosis technology, and automation technology for rationalization of maintenance and protection of equipment and facilities. Moreover, products must be diversified in response to diversified demands. Thus a technology for automated, small-scale production of diversified goods, a production facility which is different from the conventional mass production facility for the production of a single object, and production management technology for small-scale production of diversified goods are all in need of development. An assembly technology which is universally applicable to small-scale production of diversified goods is also necessary.

On the other hand, computers are being used for factory management in many ordinary machine-processing factories in the field of production management. However, computers have not yet completely taken over the entire management process, including planning the production process, assigning work to the production facilities, making decisions concerning the daily work sequence, and issuing work orders. In the iron and steel industries, computer-controlled production management is being practiced in part. The factory operation is controlled on line, in order to manufacture products with uniform quality according to plan. Many problems need to be solved before this form of operation can be applied to a factory practicing small-scale production of diversified goods.

Delay in the development of peripheral equipment which will maintain surveillance over daily operations and will keep records of the actual production process on site is also quite conspicuous. This information must be collected and processed in time by the central computer which, in turn, will issue action commands appropriate to the circumstances. If any one of the production facilities should break down, a timely command appropriate for the circumstance must be issued, so that the flow of process may be rerouted. It must also carry out production management, providing timely supply of parts to the assembly factory and keeping the stockpile as small as possible. Development of both software and hardware for application of computers in the area of management is strongly desired.

So far, we have discussed automation of production activities using mainly machine processing as an example. Development of machining centers is one of the most typical practical examples of automation. A group of machine tools in combination with a pallet magazine are controlled by a central computer. An example of a system which is in actual operation runs as follows: When the descriptions of an ordered product are fed into a computer, they are broken down into parts and checked against the inventory, and arrangements are made for its production. The raw materials are taken out of an automatic warehouse by means of an automatic conveyor and then transported by an automatic transport system to the process line. The diversified production lines consist of a DNC system in which each NC machine completely processes the work automatically. On site, the raw materials and semifinished goods are handled by manipulators. The flow of work being processed is firmly under control, and the finished parts are transported to the assembly factory. Products are assembled automatically according to the assembly schedule, automatically inspected, painted, packaged, and then shipped.

This type of system works well only when the flow of material and information is harmoniously matched. The technical information system consisting of product design and process design, the management information system consisting of production plans, load plans, and daily schedules, and the material flow system which handles the movement of materials from raw to finished form must all be compatible with one another.

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SCIENCE AND TECHNOLOGY

ENTRY OF PRIVATE SECTOR INTO DATA COMMUNICATION INDUSTRY UNDER STUDY

Feasibility Study

Tokyo NIHON KEIZAI SHIMBUN in Japanese 4 Jan 81 p 1

[Text] Minister of Posts and Telecommunications Yamauchi issued a directive to Nippon Telegraph and Telephone Public Corporation (NTTPC) to examine the de-control of transborder data flow. Japan's domestic communication business is a NTTPC monopoly. In recent years there has been a growing feeling in the industrial and academic circles that the civilian business sector ought to be allowed to participate in data communication field and that users will benefit from the competition in services among NTTPC and private data communication businesses. The minister's directive was issued in response to this upsurge of opinion. NTTPC accepted the minister's instruction and will conduct a full-scale examination of this issue. It is expected that some sort of conclusion will be published before the end of 1981.

The instruction from Minister Yamauchi stipulated that NTTPC conduct a comparison study of the current state of its data communication service, and criticisms addressed to it and the substance of the de-monopolization argument with a view to deciding how far civilian enterpreneurial participation may be authorized. Minister Yamauchi states that, "Should permitting entry of civilian enterpreneurs into the data communication sector lead to a red balance sheet for NTTPC's data communication department with the result of higher telephone charges, then such a move would not be desirable." However, he also indicated that circuits should be opened up within limits--in so far as such a move would not cause NTTPC's data communication section to go into a deficit.

Minister Yamauchi also disclosed that the Ministry of Posts and Telecommunications intends to investigage (1) the extent of permissible civilian enterpreneurial participation--up to which service level should such participation be allowed; and (2) the method for deciding the operational format, geographical distribution and numerical limitation of participating businesses and so on in the event of allowing added value DP enterprises (businesses that would lease NTTPC's circuits in order to sell communication services) to come in; and to confer with NTTPC with regard to these matters. Moreover, in regard to laws and regulations concerning this issue, his Ministry will investigate whether or not circuits can be opened within the framework of the existing regulations (public telecommunication law and so on) which stipulated NTTPC's monopoly. The ministery, however, declared that if need be, he is open to amending the law.

The noteworthy item in all this is that the survey topics include recognition of added value communications enterprises. Once it goes through, NTTPC's monopoly will in fact be broken and a new communication service industry will be established. From the user's point of view, the introduction of competitive principle into data communication field means possibility of access to highly sophisticated communications services at a low cost.

Even if the added value communication business is not authorized, many new alternative utilization formats--which will effect broad rationalization of data communication among businesses--are possible: (1) A user of a private line may offer communication services to others in addition to using it himself. (2) A private circuit network which joins enterpreneurial groups and/or communication network of private circuits joining related businesses--from manufacturers to retailers--may be established. Thus, future developments will be closely watched.

Will NTTPC's Monopoly Be Broken?

(Commentary) In data communications two alternative courses are offered: (1) a public data communication network in which anyone may participate by simple subscription and (2) private circuit that can be rented from NTTPC and with which one can establish an unique private network. The present directive by the Minister of Posts and Telecommunications has to do with deregulation of the private network.

With regard to the use of a private line, at present following practices are in principle prohibited: (1) "third party use"--use by persons or businesses who are not leasing the line, (2) "common use"--use by multiple number of persons or businesses, and (3) "reciprocal linking--linking up with a line leased by another. When these restrictions are removed, it would be possible to lease a circuit from NTTPC and offer services identical to those offered by NTTPC in competition--that is to say, NTTPC's monopoly will be broken. The fact that the Minister of Posts and Telecommunications pressed for softening of regulation not only means dissolution of NTTPC's monopolistic control of the data communications field but also signifies that the Japanese Government's policy regarding data communication is about to change.

In the United States today where communication is generally (in principle) free, there are two added value communication firms in operation--TIMENET and TELENET. The fact that the services marketed by these two firms are available at low cost spurred rapid development of the American information industry. For example, the NEW YORK TIMES' data bank operation was in the red in the beginning, but as a result of making use of the above noted low cost service and the subsequent decrease in the communication cost, it's diffusion was rapid and now, it is running smoothly.

Each year, for the last 3 years, the Ministry of Posts and Telecommunications has been studying the "Data Com-unications Regulatory Plan" (temporary designation) for presentation at the Diet--a program aimed at opening a portion of private line but it has not been able to coordinate the matter with NTTPC and the related governmental organs to bring it into reality. As the minister's instruction calls for a broader de-regulation than the previous "Data Communications Regulatory Plan"--for instance, it includes added value communication in its program--significant resistance from NTTPC is antitipated. But the circumstances now are so vastly different from the previous attempts--informal designation of Hisashi Shinto, a man from the civilian sector, as the new president of NTTPC and the Japan Federation of Economic Organizations and the industrial world clamoring for de-regulation and a political level adjudication is working along the same line--that there is a strong possibility that a major de-regulation program will be implemented.

'NIHON KEIZAI SHIMBUN' Editorial

Tokyo NIHON KEIZAI SHIMBUN in Japanese 13 Jan 81 p 2

[Editorial: "Meaning of Information Society and Data Communication Line De-Regulation"]

[Text] Minister of Posts and Telecommunications Yamauchi recently directed Nippon Telegraph and Telephone Public Corporation (NTTPC) to study the question of to what extent de-regulation of communication circuits is possible. De-regulation of communication circuits is seen as an epoch-making direct "plus" for the data communication service industry. But that is not all of it. Thought materials procurement question was resolved toward the end of last year, the second battle over the U.S.-Japan telecommunications system--which is expected to take place later this year--was the real issue of the line de-regulation.

In other words, the currently effective Japanese telecommunications law has become obsolete in the light of rapid advancement in telecommunications technology and the time has come to implement basic overhauling of the law. Moreover, it is expected that circuit de-regulation will speedily expand the exchange of information--both qualitatively and quantitatively as well as in terms of distance. The issue of "public disclosure of information" must be discussed with full consideration paid to the direction that this kid of technologial and systematic reformation is taking.

The Japanese telecommunications law is based on the concept of telephone conversation service under NTTPC's monopolistic control. Though data communication service articles were appended to the law, they are strictly appendages and merely recognize civilian data communication under strict restrictions. Induction of digital principle into communications technology has enabled a much larger data volume flow than a mere telephone conversation. Nevertheless, data communication is theated as a step-child. That is the first problem.

Danger of Information Monopoly

NTTPC is, however, not unaware of this state of affairs. To the contrary, it is well informed regarding the potential of data communication service and hopes to commercialize it on its own. That is the root of the second problem.

As a result of leveling of telecommunication network diffusion, in order for NTTPC to further increase its revenue, it must rely either on increased telephone charges or on launching an enterprise in fields other than telephone. Its move to enter the information industry can be seen as a defensive maneuver in terms of its business operation. But NTTPC must not forget that it has monopoly of telecommunication netowrks. It can use its own communication network at will to develop a new information system. The civilian information enterprises, on the other hand, must pay a high circuit access fee and the use thereof, too, is strictly regulated.

NTTPC as often said that although it will supply data communication lines, it will not compile data, and therefore, it will not become an added value communications business. Indeed, it is true that DEMOS (Scneitific and Technological Tabulation Service) and DRESS (Retail and Stock Management Service) developed by NTTPC do fall into this classification. ICAS (International Computer Access Service) and VENUS (International Public Data Communication Service) that it has developed in cooperation with the International Telegraph and Telephone Corporation, too, merely involve offering of circuits, at least at the present time.

But in the case of CAPTAINS (Ideographic and Diagrammatic Communications Network System), already at a testing stage and about to be commercialized,data supplied from outside are stored, processed and sent; and it is possible to use DRESS AND DEMOS as data banks. There is a danger of circuit monopoly leading to information monopoly.

This fact and the criticism from the United States have a common feature. In the case of the United States, the telecommunication networks are operated by civilian enterprises and thus free access to circuits is accepted as a matter of course. Long distance costs--even if one pays a circuit access fee--is unbelievably low. Moreover, whereas in Japan the "private line contract" does not recognize access of the same line to others (general users) and the use is restricted to "private" users, American telephone companies are simply a common career and the information industry is in the hands of VAN (value added network) businesses.

The American VAN businesses have been trying to make inroads into Japan for a long time but up to now, they have been hampered in their efforts by the thick barrier put up by NTTPC. Therefore it is certain that this issue will come up as an important topic for debate in Japan-U.S. negotiations in the future. One should take heed of the fact that the circumstances now are entirely different from last year's materials procurement issue where high level technology and a large market were already in existance in Japan. The largeness and the strength of the United States--not evident for sometime--is once again demonstrated in the U.S. data communications industry. This is a result of none other than NTTPC's long-standing and complacent monopoly system which has delayed the growth of the Japanese value added communications industry.

Circuit De-Control Is a Welcome Event, But...

Although communication circuit de-control request came entirely too late as it was, it is doubtful that without a directive from the Minister of Posts and Telecommunications, NTTPC would never have initiated the move on its own. In this sense, the minister's proposal ought to be applauded but because circuit de-control had been delayed by approximately 20 years, Japan faces a big problem. Twenty years ago, de-control on solely domestic basis would have worked with minor adjustments. But today, it is not so simple. Domestic de-control is directly tied to overseas de-control. A good deal depends on one's evaluation of the technological level of data communications industry in Japan and how one interprets the peculiarity of the Japanese DP market. However, the optimistic view that circuit de-control will bring nothing but good to the Japanese data communications industry--though that may indeed be so in the long run--may be unwarrantable in the short run.

NTTPC may perhaps want to take on the powerful U.S. data communications enterprises on its own. In that event, the match may be quite well balanced, if we are only considering the power factor. But then, the Japanese civilian data communications industry would not develop. It would only promote national monopoly of information which is a point of concern. In advancing the circuit de-control policy the government ought to have both the long-term perspective and the short-term focus. That would be the realistic and proper course to take.

Over the question of regulations governing public disclosure of information, debate over what exactly is information has flourished. In the course of it, the most salient misconception was the opinion that uniform and concise information ought to be prepared by selecting and eliminating injurious and useless infromation or duplicate information from among the voluminous amoutn of data. The wording of it appears to be truly efficient and one feels as if the essence of beneficial information would emerge thereby. But this argument disregards the question of who decides what is beneficial and what is injurious. What is the standard for selection and elimination in an effort to draw up a compact information.

In a free information society, voluminous data representing various viewpoints, perspectives, circumstances are generated and processed. The selection of data ought to be left to the initiative of free citizens. Government should not direct or coerce in this field. The Government's power will be further strengthened by monopolizing data. All the more reason why further concentration of data ought to be avoided.

LDP Committee

Tokyo NIKKAN KOGYO SHIMBUN in Japanese 5 Feb 81 p 14

[Text] The Liberal Democratic Party's policy body regarding information industry--League of Diet Representatives for Promotion of Information Industry (chairman: Masashi Kuranari, Member of the Lower House. Membership total - 170) has decided to establish a Line Data Processing Committee in order to seriously tackel the de-control of DP line. The League will appoint a committee chairman in the near future; at the same time, it will hold research symposiums at regular intervals and while working in close conjunction with the Japan Federation of Economic Organizations (chairman: Kisaburo Ikeura, Nippon Kogyo Ginko President), it will re-examine the problems relating to de-control of DP lines over an extended period. The plan is to establish a League policy regarding this matter by the end of this year. Japan's domestic DP industry is a monopoly of the Nippon Telegraph and Telephone Public Corporation (NTTPC). In recent years, the opinion that the civilian business sector's participation in data communication in competition with NTTPC is the desirable course of action for the users, is becoming dominant in the industrial and academic circles. Immediately after the New Year, Minister of Posts and Telecommunications Yamauchi directed NTTPC to examine the issue of significant DP line de-control and thereby quickened the pace of events. The fact that the League has now decided to take up this issue indicates that the DP line de-control will be scrutinized at the political level. Heated debate is anticipated over the question of whether DP line de-control will be implemented within the frameowrk of the existing law (public telecommunications regulations) or will involve revision of the existing law.

Data communication involves sending of information and data via telephone line hooked up to a computer. As of the end of 1979, 4789 systems--such as deposit receipts and payments of banking institutions and transportation services seat reservation--have been developed. The above figure represents the 15-fold expansion from the time of initial recognition of data communication in the public telecommunications regulations (1971). Ninety percent of this number, however, is employed within individual businesses and use in intrabusiness communication and among the general public has not advanced significantly. Data communication industry operates under a competitive format involving NTTPC, IBM, Fujitsu, ltd. and so on (total of 83 firms). There have been complaints from the industry at large that the regulations are too restrictive and that they hamper business expansion. Moreover, compared to other countries Japan's communication line use cost is high and some feel that for Kokusai Denshin Denwa (KDD) to pour in profit from its monopoly operation into data processing field is unfair competition.

As a result, Minister of Posts and Telecommunications Yamauchi directed NTTPC to de-control its DP circuits. It ruges re-examination of NTTPC's data communications service as it stands today and the critidisms and monopoly-moderating proposals addressed against the existing practice. It calls for a decision as to how far the civilian entrepreneurial participation can be allowed. The Ministry intends to confer with NTTPC as to (1) what level of service the civilian DP businesses may be allowed to offer the (2) the operational format, regional distribution, number of participating firms and so on in the event of recognizing added value communications industry which will lease lines from NTTPC.

In view of the circumstances, the League has decided to survey and study the opinions of industrial policy planning forums, scholars, NTTPC and the communications equipment manufacturers. It hopes to make this issue one of the chief pillars of the Liberal Democratic Party platform for the next year (1982).

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