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Planning Research—Mechanical Engineering
Need for Priority

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RESEARCH PLANNING—MECHANICAL ENGINEERING NEED FOR PRIORITY

SCIENTIFIC and technical research could play a definite role in national industrial development if national priorities are worked out, the research potential of the country is geared to working for national priorities and the organisation of research is toned up to meet the demands of a well directed, project-oriented and time targetted research.

In an earlier paper[1] it was shown that major areas of national investment in industries, and the areas of import were not the areas of major research investment in India. In other words if the areas of major industrial investment and the import substitution could be taken as major national priority then the investment in research has not been concentrated in those areas.

Import substitution and export promotion could be taken as a major national priority. If the areas of import could be taken as a rough index of priority than after food, the machinery and mechanical goods assumes considerable significance in terms of research priorities. In this paper the relationship of current research in relation to national needs are discussed.

In a serious effort to gear up the economy and give necessary fillip to the industry, India would have to tackle this problem of indigenous manufacture of the machinery, machine parts which are imported in the country and also look towards possibilities of export promotion. Such an effort would require a concrete research programme to attain specific goals in a specified time. It would also require the necessary allocation of resources and necessarily efficient administrative procedures to meet the requirements of the time schedule. Further, it would of necessity mean a full utilisation of the existing machinery for research, including the universities in a collaborative effort.

1. Lok Udyog, Vol. I No. 3, Pp. 67-74.

A highly developed engineering industry is an important factor in achieving rapid economic growth and consequently a high level of Gross National Product. The importance of machine building and mechanical equipment manufacture is immediately recognised when it is understood that the burden of most technologies, mechanical or non-mechanical, falls upon mechanical engineering ultimately. The key role of mechanical engineering to sustain an industrial economy, which means sustenance of all technology, chemical fertilizer, pharmaceuticals etc. needs to be clearly grasped. The utilisation of all technologies, by and large, is through the agency of machines or mechanical engineering in one sense or the other. Electrical machines are also 80 percent mechanical engineering in design and manufacture. This is also a basic element in achieving economic independence. Machinery and equipment are the foundations of an industrial economy and degree of industrialisation is often illustrated by the proportion of engineering out-put to the whole industrial production. In highly advanced nations this is well over thirty percent.

Table 1 gives the values of output and value added in organised industries in India between 1960-61 to 1965-66 and projected to 1975-76. In 1960-61 the output of all engineering industries taken together came to about 17 percent, of which the output of machinery and transport equipment, totalled about 11 percent. In 1965-66, in a period of five years, the output of all engineering industries rose to 23 percent, indicating a trend of increasing industrialisation, and of this output of machinery and transport stood at 17 percent. In value it is seen that the machinery output has nearly trebled from 1960-61 to 1965-66, a very significant trend, since the growth in machinery industry is basic to the growth and pace of industrialisation.

TABLE 1 : **Value of output & value added in organised Industries**

(Rs. million)
(at 1960-61 prices)

	1960-61		1964-65		1965-66		1970-71		1975-76	
	Value output	*Value added*	*Value output*	*Value added*	*Value output*	*Value added*	*Value output*	*Value added*	*Value output*	*Value added*
Total Census Sector	31103	8520	43316	12156	45532	12906	97475	28410	157113	46338
Machinery	1235	420	2575	899	3237	1139	10968	4002	19497	7328
Transport Equipment	2618	868	4376	1515	4713	1659	9186	3177	14879	5065
*Metals and Primary Products	3250	840	5892	1503	6141	1542	18141	4504	30374	7555
+Electrical Engineering	945	303	1718	535	1905	628	5916	1851	9793	3112
@Electronics	56	17	102	31	121	38	1040	554	2410	1074

* Includes steel castings, steel pipes and tubes, steel structural fabrication, steel wire ropes, hurricane lanterns, razor blades, utensils, etc.

\+ Turbo generators, motors, meters, cables, air conditioners, refrigerators, etc.

@ Includes Electronics measuring and testing instruments, tubes, transistors etc.

Source : Draft Fourth Plan : Material and Financial Balances 1964-65, 1970-71 and 1975-76 P.P. Div : P. Commission 1966.

FIG.1

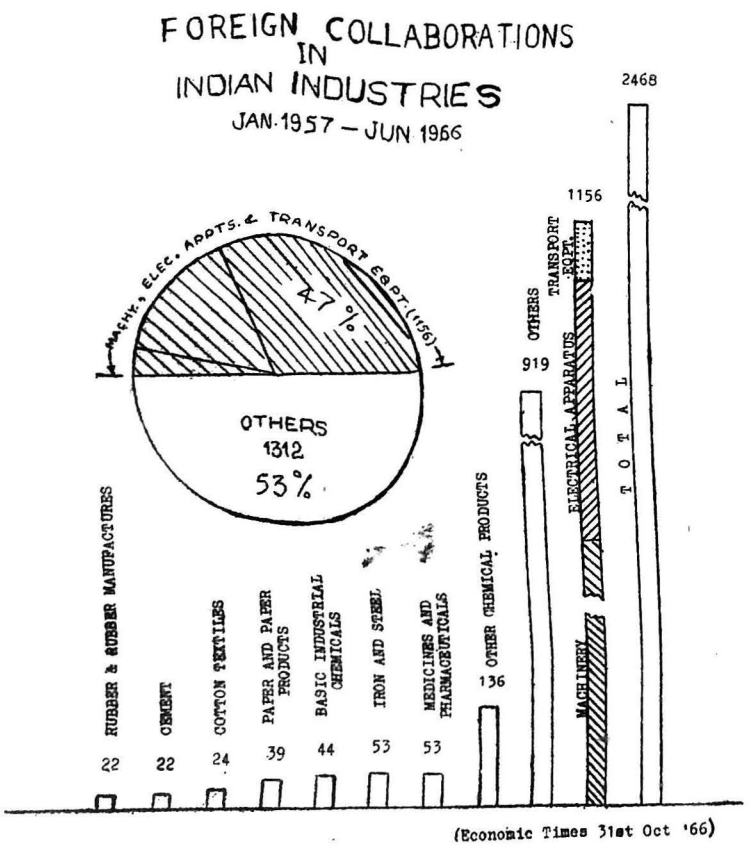
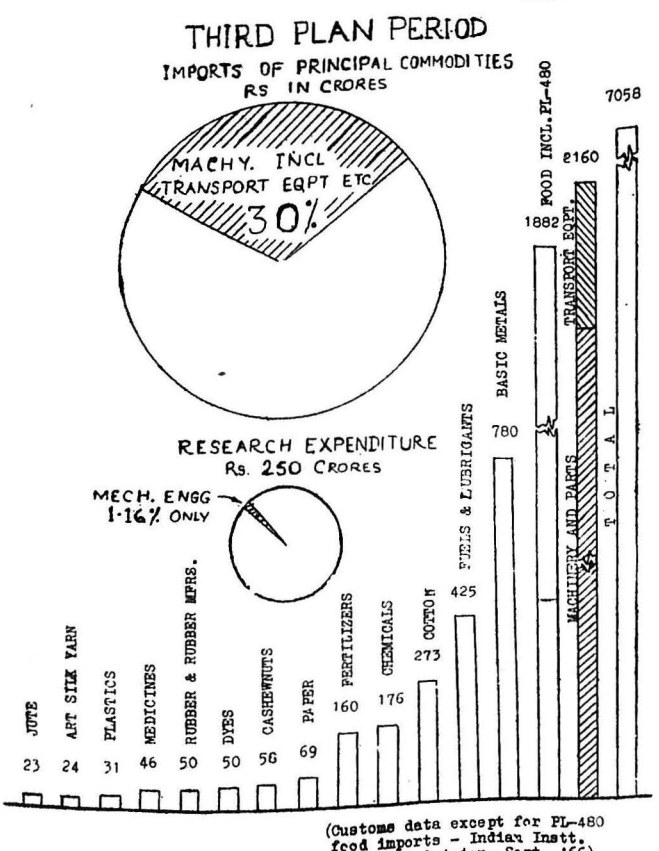


FIG.2



It is also pertinent to observe that the rate of growth of machine building activity is the highest amongst all the organised industrial sectors. Even collaboration in non-mechanical engineering technology, e.g., fertilizer industry, to be sustained, requires 10 or more specialised technical collaborations in mechanical engineering (viz., the technologies for high pressure vessels, high pressure pumps, special alloy steel pumps and valves, special lined vessels, stainless steel pipes and welded joints, huge salt scrappers, automatic weighing and bagging equipment etc.)

Figure 1 shows an analysis of all the collaborations sought in the country between the period January, 1957 to June, 1966—a period in India's history of industrialisation when the bulk of the techology has been borrowed. This clearly brings out the importance of mechanical engineering. Collaboration agreements for the manufacture of machinery and transport total 47% of all the collaborations sought.

Again another important index to reveal the status of mechanical engineering and machinery is provided by analysis of import and export trade of the country. An examination of the import figures (Table 2) confirms that nearly one third of the imports is accounted for by machinery and transport equipment. The latter accounted for Rs. 332.98 crores out of a total of Rs. 1121.62 crores worth of import in 1960-61. Even the engineering industries having registered nearly six percent growth over 1960-61, the position in 1965-66 was that out of a total import of Rs. 1394 crores, machinery and transport equipment accounted for Rs. 489.47 crores—nearly 35 percent. Import of other manufactured goods (Rs. 234 crores in 1965-66) again reflects dependence on specialised mechanical engineering technology, and lack of special purpose machine building industry without which these goods cannot be produced in the country. During Third Plan, out of total imports of Rs. 7058 crores, machinery accounted for Rs. 2160 crores i.e., 30% as shown in figure 2. If the food imports are excluded it is seen that dependence on mechanical engineering imports nearly equal the import of the fruits of all other sciences and technologies put together. During the Fourth Plan dependence on machinery and equipment is estimated to rise to 40% of the total imports and is estimated at Rs. 5,000 crores.

The dependence for maintenance imports is also very pronounced. Table 4 shows maintenance imports during Third Plan. Nearly a ninth of these imports comprised of machinery and transport equipment. Table 5 shows imports for a group of engineering industries as per cent of value of production. The same table also shows the percentage of capacity utilised. While it may be that in certain cases the idle capacity is due to lack of basic materials, in many cases it is due to non-availability of designs and technology of manufacture.

In spite of the fact that the engineering industry in India is among the best of the developing countries, no serious attempts have been made to orient the industries for export. Table 3 shows the export figures from 1960 to 1966. In 1960-61 out of a total export of Rs. 632.42 crores, only Rs. 3.68 crores worth of machinery and transport equipment was exported. The total for all engineering commodities stood at Rs. 8.47 crores. In 1965-66, when the total exports stood at Rs. 802.09 crores, the value of machinery and equipment exported amounted to Rs. 10.46 crores. The export of all engineering commodities put together amouted to Rs. 24.43 crores. Even though the export of engineering goods forms a minor portion in our total exports, it is noteworthy that while the total export growth between 1960-61 and 1965-66 has been 1.4 times, the engineering exports have registered a three-fold growth.

The remedy therefore for reducing imports and pushing up export lies in the development within the country of requisite mechanical engineering know-how. The country has now the necessary capacity to produce most of the machinery requirements. Imports are resorted to, since the requisite designs and know-how for their manufacture are not available, and exports are limited because of the cost of production, quality and range of the products being limited.

Obtaining licences to import of know-how is no complete answer for an underdeveloped country. Licensing holds promise of gaining time, provided the pitfalls of foreign licences, their merits and

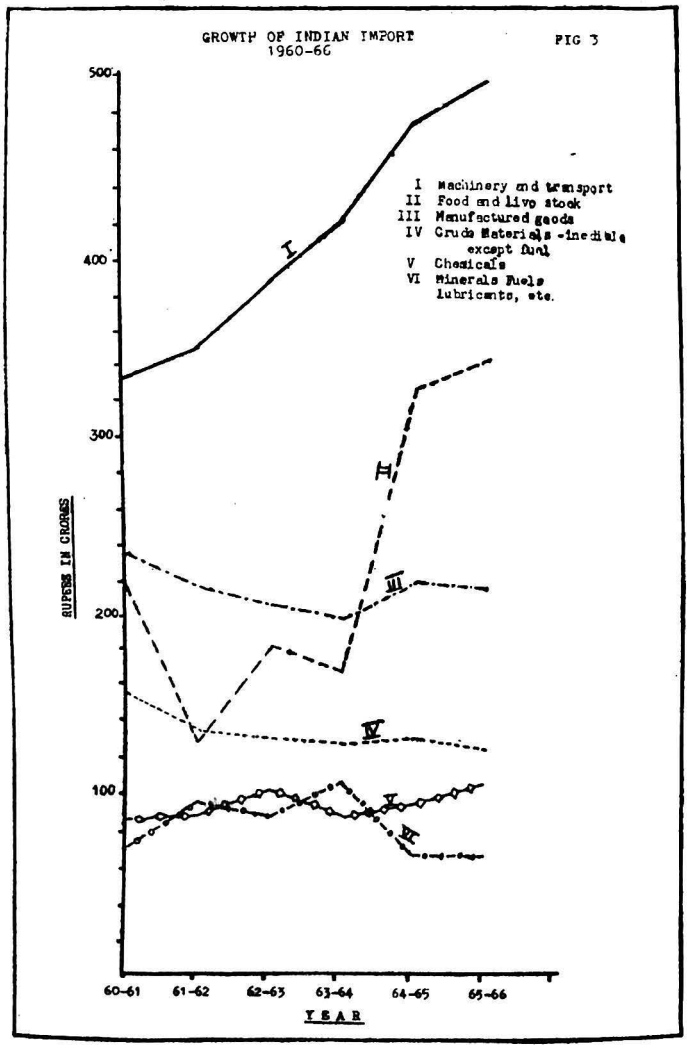

GROWTH OF INDIAN IMPORT
1960-66
FIG 3
500
400
300
200
100
RUPEES IN CRORES
I Machinery and transport
II Food and live stock
III Manufactured goods
IV Crude Materials -inedible except fuel
V Chemicals
VI Minerals Fuels lubricants, etc.
I
II
III
IV
V
VI
60-61
61-62
62-63
63-64
64-65
65-66
YEAR

TABLE 2 : **Import of important commodities during 1960-66**

(Rs. in crores)

	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66
	(1)	(2)	(3)	(4)	(5)	(6)
1. Food and livestock	214.06	126.44	179.41	163.01	322.72	340.82
2. Tobacco and Beverages	0.79	1.58	1.66	1.07	0.77	0.55
3. Crude Materials-inedible except fuel	155.36	129.53	127.20	122.58	128.34	121.55
4. Mineral Fuels, Lubricants and related materials	69.52	95.85	87.97	104.52	68.67	68.35
5. Animal and vegetable oils and fats	4.60	8.53	5.63	4.87	5.62	15.35
6. Chemicals.	85.70	88.80	100.52	88.40	94.54	104.85
7. Manufactured Goods	234.16	213.13	203.95	195.53	218.58	215.85
8. Machines & Transport Equipment	332.98	348.92	387.38	421.57	477.74	489.47
9. Misc. Manufactured articles	17.40	20.19	30.72	35.38	22.70	18.62
10. Unclassified Commodities	7.05	5.67	7.03	6.67	9.35	16.56
11. Grand Total (incl. articles under reference)	1121.62	1038.64	1131.48	1143.60	1349.03	1394.05

TABLE 3 : **Export of Major items from India 1960-66**

(Rs. in crores)

	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66
1. Food and Livestock	198.03	214.23	233.93	248.48	261.23	241.38
2. Tobacco and Beverages	15.75	14.96	I8.87	21.70	25.78	21.70
3. Crude materials-inedible except fuel	111.92	118.08	111.02	131.31	137.33	134.91
4. Mineral fuels, lubricants and related materials	7 41	5.91	6.47	7.71	12.26	9.32
5. Animal and Veg. oils and fats	9.80	6.50	13.65	20.43	7.38	4.55
6. Chemicals	7.16	7.84	7.81	6.54	10.23	11.46
7. Manufactured Goods	262.73	271.00	266.46	298.66	326.25	342.98
8. Machy. & Transport Equipment	3.68	3.93	4.31	5.47	8.59	10.46
9. Misc. Manufactured Articles	11.58	10.18	11.05	17.67	19.93	21.60
10. Unclassified commodities	4.35	4.19	4.57	4.91	4.17	3.73
11. Grand Total (Incl. Materials received by post etc.)	632.41	656.85	678.14	762.93	813.15	802.09
Export of Engg. commodities in	8.47	9.92	9.84	14.64	19.63	24.43

demerits, are administratively grasped with clarity. Most of those who have been responsible for working licenced industry, have felt that many of processes do not fully cater to the particular needs of the country. Even the vastly different practices, for example, between the British and the American industries can often be explained by saying that each is doing a sensible thing in its own circumstances. The first requirement of a licensed product is its adaptation to Indian environment, and very particularly to Indian materials. This calls for indigenous research and development. The Second Report of the UN Economic Social Council's Advisory Committee on Application of Science and Technology to Development (May 1965) states that "available modern processes and machinery in some important industries are poorly suited to the needs for developing countries because they are large scale, single purpose and capital intensive. The relatively small markets and consequent need for flexible and versatile equipment, the scarcity of capital and relative abundance of labour, yet the need for efficient means of production to modern standards of quality, make the characteristics of equipment for developing countries quite different from the characteristics sought in highly industrialised countries. Equipment suppliers in developed countries in many cases have neglected the need and potentialities for machinery and equipment to meet the special needs of the developing countries. The committee believes that more attention should be given to the needs and opportunities presented by the gap in technology". Adequate attention is thus needed to be given to mechanical engineering research and development within the country, to develop indigenous designs of machines, plants and technology suited to Indian raw materials.

While the burden of our dependence squarely lies upon mechanical engineering, research effort in this field during the Third Plan period (Fig.2) has been very meagre indeed. The total research expenditure in this field, though not known, can be roughly estimated to be around Rs. 3 crores forming a mere 1.16% of the total Rs. 250* crores expenditure on scientific research in India. It can be surmised that the critism against Indian scientific efforts, that the results have not been commensurate with expenditure, and that no impact of the Indian Science on the Indian Economy is not perceptible derives directly from the lack of support to machinery and equipment research, which could transform laboratory processes to saleable production in commercial volumes. The lack of support for mechanical engineering research is rather an unfortunate neglect in the planning of scientfic research and the rapid industrialisation of the country. An analysis of expenditure in this field compared to the total research expenditure in some foreign countries is made in the following paragraphs to indicate the emphasis placed on this mechanical engineering.

Table 6 gives an analysis of manufacturing companies in different sectors of industry in the United States of America in the year 1958 and the research expenditure in these sectors. Nearly 20% of the total research expenditure was incurred on research in machinery and transport equipment. The research expenditure in these fields has considerably exceeded even the new capital expenditure incurred in that year. This shows the relative importance attached to research on mechanical engineering in U.S.A. Table 7 shows industry-wise total research funds spent by U.S.A. between the years 1956-63. The rate of expenditure on research in machinery and transport sector has been in tune with the general rate of growth of the total research expenditure. The expenditure on mechanical engineering research had doubled over a period of eight years. Again if it is considered that a major portion research and electrical engineering research comprises of mechanical engineering research the actual inputs for mechanical engineering would appear phenomenal indeed. In fact, in a developing country like India, expert opinion would point out that the need for application of science requires greater developmental efforts in mechanical engineering than in a developed country like the United States of America.

An analysis of expenditure on combined research activities in France (Table 8) also bears out the fact and that mechanical engineering research (Mechanical Energy Conversion) formed 15% of the total research effort. Again the following remarks pertaining to France* are also relevant in this connection.

*M.M. suri "Key-note address on Know-how" Colloquium on Industrial Development. Hindustan Chamber of Commerce. Madras 1966.

*OECD Reviews of National Scince Policy-France. 1966.

TABLE 4 : **Estimated Requirement of Maintenance Imports for the third Plan**

Commodities	Rupees in crores
1	2
Fertilizer	200
Dyes and colours	50
Drugs and medicines	38
Other chemicals	210
Petroleum and products	539
Iron and Steel	182
Non-ferrous metals	303
Machinery	304
Transport equipment	103
Raw cotton	145
Raw wool and wool tops	58
Raw jute	4
Textile yarn and thread	93
Newsprint, paper and board	50
Wood and cork	27
Rubber	38
Hides and skins	10
Gums, lacs, resins	14
Copra	52
Vegetable oils	18
Milk, fish, spices	69
Fruits, nuts and vegetable	100
Cereals (not including PL 480 aid)	18
Tobacco	6
Other imports	944
Total :	3,570

Source : NCAER Study on Maintenance Imports.

TABLE 5 : **Imports as per cent of value of Production and Production as % of capacity for a group of Engineering Industries**

Item No.	Industrial classification	Import as % of value of production	Production as % of capacity (1965)
1	2	3	4
1.	Construction machinery, excluding earth moving.	5	(Incandecent) 102.6
2.	Electric lamp fluorescent tube etc.	8	92.8 (flourescent)
3.	Domestic refrigerators	10	123.7
4.	Bicycles	10	—
5.	Pumps	10	122.1
6.	Fans and blowers	10	95.3
7.	Sugar machinery	12	—
8.	Electric motors	15	125.8
9.	Ball and roller bearings	15	71.3
10.	Air compressors	15	—
11.	Chemical machinery	16	
12.	Room air-conditioners	18	
13.	Industrial air-conditioning machinery	18	56.8
14.	Grinding wheels and coated abrasives	20	85.9
15.	Road rollers	20	75.2
16.	Machine tools	25	76.2
17.	Furnaces, etc.	25	—
18.	Automobile ancillary	25	—
19.	Motor cycles, scooters and three wheelers	26	—
20.	Boilers	28	—
21.	Storage batteries	30	—
22.	Commercial vehicles	30	
23.	Jeep and cars	30	
24.	Cutting tools and other small tools	33	84.3
25.	Jute textile machinery	35	—
26.	Earthmoving and materials handling equipment	40	
27.	Diesel engines	40	96.4 (vehicular) 121.5 (stationary)
28.	Coal mining and washery equipment	42	—
29.	Cotton textile machinery	45	36.2 (100 ms)
30.	Agricultural tractors and tillers	45	
31.	Winding wires; enamelled and paper covered	50	82.4
32.	Paper insulated and power cables	55	70.9
33.	ACSR and AAC conductors	60	70.4

Note : All capacities have been assessed on as one shift basis.

Source : NCAER Study on Maintenance Imports Handbook of Statistics of Indian Engineering Association 1966.

"Mechanical engineering is very unevenly provided with research institutions; although the manufacture of locomotives or other heavy equipment is preceded by a good deal of research light, engineering, machine tools and precision engineering are less well provided for. The protection enjoyed by certain sectors within the national frontiers, the wide dispersion of firms which hampered establishment of research units, and a certain conservation on the part of the country's leaders who did not all grasp the importance of research, all explain why France has already fallen behind the UK and Germany".

Estimated distribution of industrial research and development expenditure in the year 1962 in United States, Belgium, France, Germany and U.K. is shown at Table 9. Nearly a fifth of the total expenditure in U.S.A. and Germany is in the field of machinery, transport equipment and energy, U.S.A. and Germany are main world's suppliers of industrial machinery and equipment. France, U.K. and Belgium follow with 18, 14.7 and 11.3 percent of the total research expenditure being spent on mechanical engineering research.

The preceding description clearly shows the national and economic reasons for a greater need and emphasis on mechanical engineering research in India. The possibilities from such a policy would be evident from a few examples from which definte gains have been made. The data from the research results of Central Mechanical Engineering Research Institute is given as it was readily available. Similar data from other research organisations would strengthen the argument. The examples given below, incidentally bring out the strategy of research viz, national requirements and the possible returns from the utilisation of results of research.

(i) Cable making machinery was being completely imported till recently. Twenty different types of machines are covered in a coordinated programme of development of close collaboration with user and manufacturing industries. On account of this development, which may cost a total of about Rs. 20 lakhs, during the Fourth Plan period a saving in foreign exchange of Rs. 15 crores is estimated. Firm orders worth Rs. 2 crores has already been placed on indigenous manufacturers.

(ii) Designs for a 20 h.p. tractor are in a final stage and prototypes would be ready for field trials during the later part of 1967. The Mining and Allied Machinery Corporation, Durgapur, utilising its idle capacity could produce these tractors to meet the Plan requirements. The cost of research and development expenses is estimated at Rs. 10 lakhs *in Indian Rupees*. To the Czechoslovakians, with whom the Government of India has signed an agreement, for just the project report for this 20 h.p. tractor, we have to pay Rs. 16 lakhs *in foreign exchange* : Total foreign exchange saving on account of this development would be Rs. 20 crores to the country against the original plans of foreign collaboration.

(iii) Development of a scooter under progress to be manufactured again utilising available capacity in the industry, is expected to save the country the originally planned capital expenditure of Rs. 7.5 crores including Rs.2.5 crores foreign exchange.

(iv) New types of economical steel structures for industry save valuable steel up to 40% over conventional designs and an equal percent in cost. Assessment by the Panel of Steel Ministry's Experts shows an estimated saving of 0.5 million tons of steel (Rs. 35 crores) if the researches of CMERI are made use of in the Fourth Plan. Total saving in capital investment on structures in the country could be in the range of Rs. 70 crores, while the total cost of this research project would be below Rs. 10 lakhs.

The above examples clearly show that if research as an investment has to yield commensurate returns, careful allocation of research funds to various sectors of science and technology that have a direct hearing on social needs has to be made. It is necessary to identify particular fields of deficiencies and apportion research funds on the basis of established priorities. The key role of mechanical engineering to sustain our economy today and even to sustain any other technology, chemical, fertiliser, pharmaceutical, etc. need hardly be over-emphasised. For rapid industrialization and reducing our dependence on foreign

equipment, spare-parts and technology, the country must increase resources for mechanical engineering research. Research in this field should be diversified, and more industrial units should be encouraged, by proper fiscal policy to establish research development and design facilities. Universities and Institutes of Technology should expand their activities and diversify their curricula. Applied mechanical engineering research and development has only now made a beginning in the country. The Central Mechanical Engineering Research Institute (CMERI) established at Durgapur has only for the past three years started its effective functioning. A Central Machine Tool Institute has been started recently at Bangalore for development of designs for the machine tool industry. The Research Designs and Standards Organisation of the Ministry of Railways has been attending to the problems of Railway engineering only. In addition, the four Indian Institutes of Technology ; departments of engineering at Universities also engage themselves in basic and applied research in this field. Heavy Engineering Corporation has established a research development and design institute, to evolve indigenous designs and prototypes. The private industry has also set up research and development laboratories to evolve new machines and equipment. Texmaco Calcutta, Kirloskars Poona, Telco Jamshedpur, Textool Coimbatore, and Textiles Machinery and Allied Industries Research Association, Baroda are a few that need be mentioned in this regard.

What needs to be done is that the work of these organisations should be based on market research, planned needs and in the context of national priorities so that complementary and collaborative research programmes should be taken up at the organisations, taking into account the facilities available there. These organisations should be able to develop a national perspective, isolate the national tasks in terms of mechanical engineering, convert them to technical problems, and take them up as well defined time-targetted projects, wherever necessary resources in terms of manpower and funds are available for research in the organisation.

Besides, it would also be necessary to develop cooperative research associations and ways should be found for encouraging industrial units to form cooperative research associations. Possibilities of cooperative research associations for automobiles industry, agricultural implements industry, dairy industry, sugar machinery industry, and sewing machine industry should be actively explored and persued. New institutes to, cover new fields in mechanical engineering should be established.

It is even necessary to isolate within the field of mechanical engineering, areas which need urgent attention the requisite priorities in these fields worked out. The experience available in the Indian Industry has to be properly harnessed with the academic talent available in universities, and scientists and engineers in the research institutions to make good for the non-availability of research engineers with practical experience.

Efforts at improving quality and productivity in the existing industry could bear immediate fruits, both within the home markets and for exports. The step taken by CMERI in establishing Mechanical Engineering Research and Developing Centres in the various industrially developing areas of the country needs urgent support, speedier execution and further augmentation.

Any effort at increasing mecahnical engineering research in the country, has to carefully take into consideration the availability of research workers. Table 10,11 and 12 give the increase in number of institutions (both degree level and polytechnics for engineering institutions), their actual in-take of students; out-turn of engineering graduates and out-turn of Masters degree holders in various engineering subjects respectively. There are now 133 colleges imparting degree level training and 274 polytechnics, with intake capacity of 25,000 degree students and about 48,000 students at polytechnic level. However, the proportion of students with mechanical engineering subjects (e.g., mechanical engineering; Aeronautical engineering; Automobile engineering; Chemical engineering and Technology) is very low and has fluctuated between 27% to 29.3% till 1961 and since then it has steadily increased to 38.01% in 1965. Post-graduate training in engineering has started only about a decade ago. Table 12 shows number of masters degree holders. There is no data available to indicate the number of persons taking up research as career. But it can be safely assumed that the number would not be very high.

Attempts should be made to increase the proportional output of engineers with high mechanical engineering content. Secondly, more people should be induced to take up research as a career. It has been estimated that it takes about 3 to 5 years to train an engineering graduate to be an effective research worker through engaging them in actual research. Therefore, the policy for training of research workers should be drawn up with 3 to 5 years of time lead in the laboratories and research institutions. The universities and other academic institutions should expand their research effort to include the training of research workers. The large proportional for mechanical engineering graduates must be involved in research developmental work.

It is known that R & D expenditure in India is at an insignificant level. It is all the more necessary that the mechanical engineering research should be be given greater emphasis in the scheme of prtiorities. Investment in mechanical engineering research has to be thought of as an investment bringing out commensurate returns in its own field as well as in related fields.

While the total research expenditure is being raised from the level of Rs. 250 crores in the Third Plan to Rs. 430 crores in the Fourth Plan, the priority in allocation demands to strengthen mechanical engineering research so that it may be able to make a real impact on the Indian economy.

This study has pinpointed the need for more rational assessment and manner of research fund allocations for the many scientific disciplines, than has hitherto engaged the attention of the planners, science administrators, and the Government of India, which needs urgent correction in the context of the country's actual needs.

TABLE 6—R & D Performance in Manufacturing Companies USA-1958

$ million

	No. of Companies	*Net sales*	*Value added*	*Net capital*	*R & D Expenditure*	*R & D Expenditure as % of new capital expenditure*
1. Food and Kindred Products	35,256	61,619	17,259	1,103	83	7.5
2. Lumbers, wood products & furniture	46,067	11,861	5,188	346	10	2.9
3. Paper and allied products	3,763	10,692	5,124	572	42	7.3
4. Chemical and allied products	8,546	21,807	12,123	1,325	792	59.8
5. Petroleum & Refining & Extraction	16,145	33,489	11,591	3,658	246	6.7
6. Rubber products	3,955	6,694	3,1247	216	89	41.3
7. Primary metals	5,151	23,236	12,329	1,565	119	7.6
8. Fabricated metal product	22,889	18,112	8,842	491	133	27.1
9. Machinery	28,171	23,159	11,821	729	781	107.1
10. Electrical equipment & communication	6,781	21,685	11,169	598	1,969	329.4
11. Motor vehicle and other transport equipment	4,465	22,824	10,221	567	831	146.5
12. Aircraft & missiles	1,463	15,412	8,043	287	2,662	927.5
13. Professional and scientific instruments	3,167	4,779	2,935	152	294	193.4
14. Other manufacturing industries	99,117	61,558	30,202	1,507	193	16.2
Total	284,936	336,935	150,092	13,117	8,246	62.9

TABLE 7—**United States of America Funds for R & D performance, industry-wise**
(Includes both Federal & Company)

$ (Million)

1	1963 2	1962 3	1961 4	1960 5	1959 6	1958 7	1957 8	1956 9
Total	12686	11464	10908	10509	9618	8389	7731@	6605@
Food & Kindred Products	127	117	122	102	90	83	74	64
Textiles & Apparel	30	28	30	38	30	26	15	—
Lumber, wood products, and furniture	10	10	10	10	12	12	14	—
Paper and allied products	70	65	59	56	49	42	35	36
Chemical & allied products	1279	1190	1109	986	891	792	705	641
Petroleum refining & extraction	313	305	295	290	276	246	211	182
Rubber products	150	135	136	120	115	89	107	—
Stone, clay, and glass products	123	113	99	96	84	75	69	60
Primary metals	181	169	175	176	152	131	108	90
Fabricated metal products	158	145	135	144	137	162	135	116
Machinery	968	911	864	932	927	781	669	543
Electrical Equipment & Communication	2436	2346	2297	2406	2270	1969	1804	1516
Motor vehicles & other transport equipment	1104	1011	944	890	870	856	707	688
Aircraft & missiles	4846	4147	3904	3558	3110	2609	2574	2138
Professional & Scientific Instruments	483	439	382	396	339	294	249	200
Other manufacturing industries	94	95	158	148	130	105	93	—
Non-manufacturing industries	275	239	188	160	136	117	—	—

@ Includes those for which separate figures are not available

TABLE 8—Research Expenditure

Programme of Appropriation for Combined Activities in France

In million Francs

1	*1963* 2	*1964* 3	*1965* 4	(*Estimates*) 5
1. Electronics	19.50	15.00	17.00	
2. Computers	3.50	3.00	7.00	
3. Energy Conversion	11.00	9.40	3.60	
4. High Energy Acceleration	1.50	3.00	3.00	
5. Automation	1.00	5.00	5.00	
6. Macromolecular Chemistry	5.00	6.00	6.00	
7. Housing and Civil Engg.	1.00	4.00	4.00	

In million Francs

1	*1963* 2	*1964* 3	*1965* 4	(*Estimates*) 5
8. Earth Sciences	4.00	5.00	5.00	
9. Mechanics	6.00	6.00	6.00	
10. Exploitation of Sea	9.95	1.45	5.55	
11. Water	0.50	4 00	4.00	
12. Molecular Biology	6.30	3.50	8.50	
13. Cancer & Lukaemia	7.00	2.70	3.30	
14. Function & Diseases of brain	2.00	2.50	—	

1	2	3	4	5
15. Application of Genetics	1.25	1.70	0.55	
16. Animal and Human Nutrition	1.25	1.70	0.55	
17. Agricultural Technology	6.50	10.50	10.50	
18. Economic & Social Population Analysis	1.00	1.65	—	
19. Planning Problems	3.00	4.55	6.00	
20. Economics & Development Problem	1.50	2.55	—	
21. Measuring Instruments	—	2.20	2.20	
22. Atmospheric Research	—	0.50	2.50	
	92.50	95.60	99.90	

Source : OECD Reviews of National Science Policy—France (1966)

TABLE 9—Estimated Industrial percentage Distribution of R & D Expenditure–1962

	United States Product feld. (1962)		Belgium	France	Germany	U.K.
	(1)	(2)	(1961)	(1962)	(1963)	(1962)
Aircraft	36.3	35.3		27.7	(5)	35.4
Vehicles	7.4	5.1	0.8	2.6		3.0
Machinery	8.2	7.6	8.0	6.4		7.3
Electrical Mach.	21.6	24.1	19.4	25.7	33.8	21.7
Instruments	3.9	2.1	—	—		2.3
Chemicals (3)	12.6	10.4	39.6	16.8	32.9	11.6
Setel and metal products	2.0	2.4	13.3	3.2	6.6	2.9
Non-Ferrous Metals	0.6					1.2
Stone-clay and glass	1.0	0.5	(8)	1.2	0.8 (7)	1.3
Rubber	1.1	0.7		(8)	1.0	1.2
Paper	0.6	—			0.6	0.9
Food and drinks	0.9	5.4	2.6		0.6	1.9
Other manufacturing	2.0		13.0		1.9	3.4
Transport and Energy	—	5.4	3.3	9.0	0.6 (6)	4.4
Other non-manufacturing	1.9	—	—	2.4	2.0	1.6
Total	100.0	100.0	100.0	100.0	100.0	100.0

(1) Analysis by Industry Group. Companies are classified to the Industry of their principal activity, Industrial classification vary between countries, so this table can indicate the broad outline only.
(2) Including Ordnance
(3) Including petroleum refining and products.
(4) Including all research association
(5) Including some steel
(6) Energy only
(7) Including wood.
(8) Included under other categories

Source : OECD—The Research & Development Effort in Western Europe, North America and Soviet Union–1965.

TABLE–10—**Growth of Engineering Colleges and Polytechnics and their actual intake.**

Year	Engineering Colleges	Actual Intake	Polytechnics	Actual Intake	Year	Engineering Colleges	Actual Intake	Polytechnics	Actual Intake
1	2	3	4	5	1	2	3	4	5
1948	38	2940	53	3670	1958	83	11086	157	19932
1950	49	4119	86	5903	1959	87	11507	167	21366
1951	53	4788	89	6216	1960	102	13824	195	25801
1952	56	5184	96	6499	1961	111	15850	209	27701
1953	58	5450	92	7213	1962	114	17074	231	30826
1954	59	5468	95	8313	1963	118	21040	248	39712
1955	65	5888	114	10484	1964	131	23757	264	46243
1956	71	6612	119	10318	1965	133	24695	274	48108
1957	74	8760	129	15000					

TABLE-11—Out-turn of Engineers at Degree Level

	Subject	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
1.	Civil Engineering	712	860	1019	959	1079	1310	1521	1636	1689	1772	1964	2232	2543	2710	2613	2515
2.	Mechanical Engg.	362	510	546	546	668	937	1005	986	825	1101	1311	1833	2345	2540	2701	3136
3.	Electrical Engg.	415	555	490	410	555	716	866	777	759	724	923	1301	1688	1919	2173	2320
4.	Mechanical Electrical Engg.	70	91	107	108	53	—	—	—	—	—	—	—	—	—	—	—
5.	Aeronautical Engineering	—	—	24	6	4	3	16	10	9	8	6	8	7	8	26	26
6.	Automobile Engineering	—	—	24	23	20	23	32	31	30	20	25	24	20	26	28	29
7.	Chemical Engg. and Technology.	130	189	189	187	163	174	129	237	295	247	344	300	395	432	496	472
8.	Production Engineering	—	—	—	—	—	—	—	—	—	10	11	9	15	—	—	10
9.	Total Engineering*	1880	2404	2666	2489	2785	3479	4016	3916	3965	4296	5249	6505	7900	8592	8938	9661
10.	Total with High Mechanical Engg content.**	512	790	890	850	908	1137	1172	1300	1159	1486	1697	1910	2782	3006	3251	3673
	(10) as % of (9).	27.02	32.34	33.37	34.15	32.24	32.68	29.18	33.19	29.22	34.59	32.33	29.35	35.21	34.99	36.28	38.01

* For all branches of Engineering, including those not mentioned here.

** Sum of (2) (4) (5) (6) (7) and (8).

Source : Min : of Education.

TABLE-12—Out-turn of Master Degree Holders in Engineering

Subject	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Civil Engineering	1	—	9	6	3	20	55	124	66	
Electrical Engg.	—	—	—	—	4	10	11	77	17	372
Mechanical Engg.	—	—	—	—	1	25	21	76	16	
Structural Engg.		—	—	—	—	25	—	—	—	
Total	1	—	9	6	8	80	86	277	99