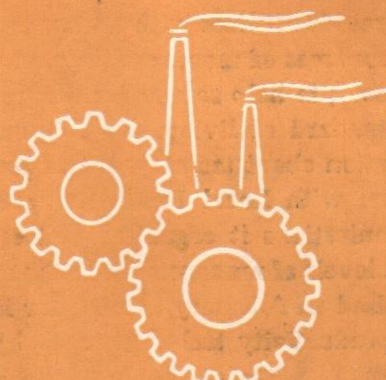
special issue on material Handling

PRODUCTIVITY

JOURNAL OF NPC



NATIONAL PRODUCTIVITY COUNCIL, INDI

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NATIONAL PRODUCTIVITY COUNCIL

The National Productivity Council is an autonomous organisation registered as a Society. Representatives of Government, employers, workers and various other interests participate in its working. Established in 1958, the Council conducts its activities in collaboration with institutions and organisations interested in the Productivity drive. 44 Local Productivity Councils have been established practically all over the country and work as the spearhead of the productivity movement.

The purpose of NPC is to stimulate productivity consciousness in the country and to provide services with a view to maximising the utilisation of available resources of men, machines, materials and power; to wage war against waste; to help secure for the people of the country a better and higher standard of living. To this end, NPC collects and disseminates information about techniques and procedures of productivity. In collaboration with Local Productivity Councils and various institutions and organisations it organises and conducts training programmes for various levels of management in the subjects of productivity. It has also organised an Advisory Service for industries to facilitate the introduction of productivity techniques.

NPC publications include pamphlets, leaflets and Reports of Productivity Teams. NPC utilises audio-visual media of films, radio and exhibitions for propagating the concept and techniques of productivity. Through these media NPC seeks to carry the message of productivity and to create the appropriate climate for increasing national productivity. This Journal is an effort in the same direction.

The Journal bears a nominal price of Rs. 2.00 per issue and is available at all NPC offices. Annual subscription (Rs. 12.00 to be sent by cheque in favour of National Productivity Council, New Delhi) is inclusive of postage! Subscription for three years, however, can be paid at the concessional rate of Rs. 32.00.

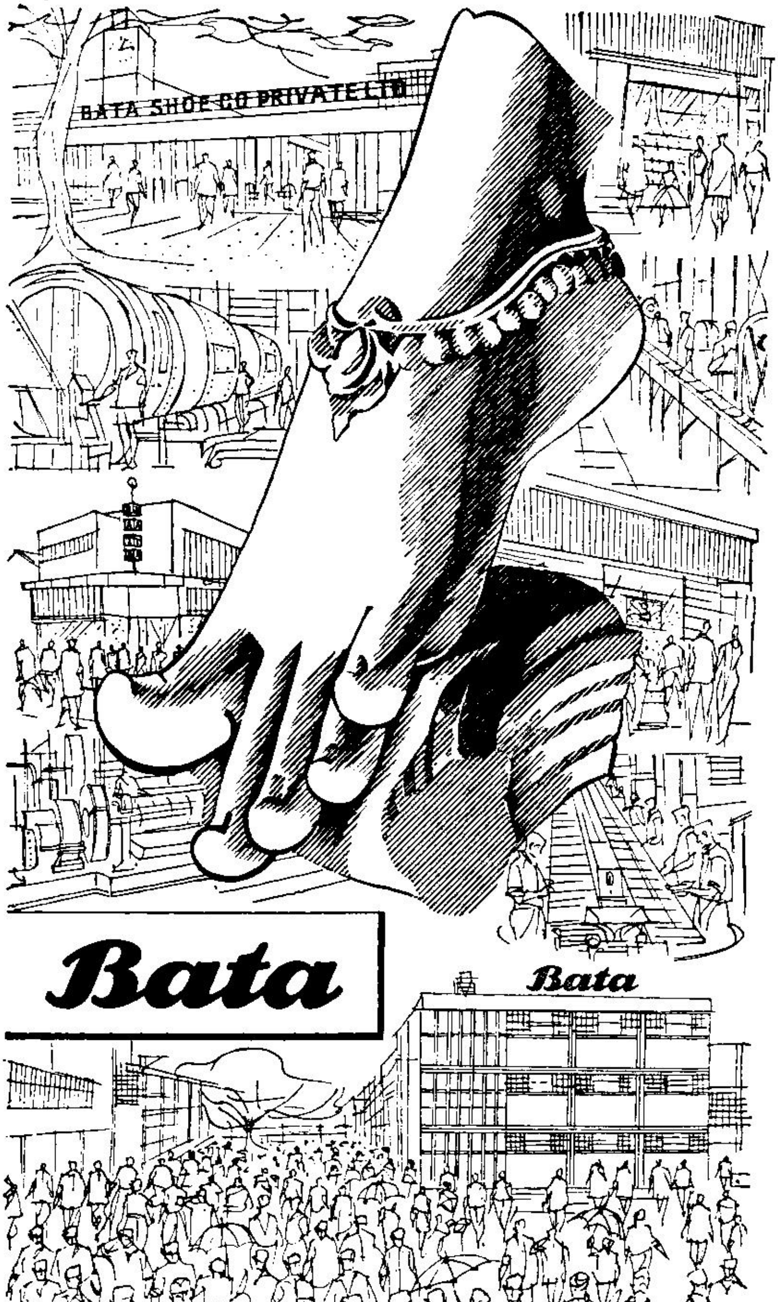
Opinions expressed in signed articles are those of the authors and do not necessarily reflect the views of NPC.

THE DAY BREAKS BRIGHTER TOMORROW

MILK. Food. Children grow straight and strong.
Today's care. Gentle as with a flower.
Today's protection. The shelter of mighty effort.
Tomorrow...a little less of care, a little more of joy.
And for HINDUSTAN LEVER, too, tomorrow begins today.
In the milk plant and research laboratory,
in the factory and office. Work, patience, care
to serve tomorrow's homes and the nation's needs
with products that grow better and better.

TODAY AND TOMORROW...HINDUSTAN LEVER SERVES THE HOME

WITH SOAPS, FOODS, TOILET PREPARATIONS


BATA SHOE CO PRIVATE LTD
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FOURTEEN MILLION NEW JOBS

The Third Five Year Plan
Bird-Heilgers' part in it...

Employment. A word that translates into a meaningful future for millions of people without jobs. India's Five Year Plans are aimed at the concept of full employment. The intensified drives of the Third Plan are estimated to create 14,000,000 new job opportunities—more jobs for more people than ever before in the economy's history! To achieve the employment target calls for a single-minded national effort. It must be co-ordinated, dedicated, complete...

75,000 jobs—and more in the offing

Bird-Heilgers is convinced that the quickening tempo of industrial activity must be accelerated if unemployment is to be checked and full employment brought about. Wedded to this concept, the group provides well-paid employment for approximately 75,000 people. They are concerned with iron ore and insurance policies, bridges and writing paper, gunny sacks and laboratory tests—a complex of goods and services which involves the group heavily in the industrial insurgence of India.

Towards a self-generating economy...

A phrase on everyone's lips. A phrase that finds concrete expression in the urgent activity of an economy on the move. Bird-Heilgers reflects the nation's striving. The group delivers millions of tons of basic materials to the new blast furnaces. It produces jute goods, paper and board, air compressors and springs, and engineering and water treatment equipment. A project for the manufacture of coal washeries was the first in India. Planned diversification finds the group engaged in shipping, insurance, exporting and importing. Its agency department handles everything from heavy capital equipment to light consumer goods.

...and an exciting, promising future

The Five Year Plans are a challenge: existing industries must expand, new industries open up, per capita income increase. India needs more goods and services than ever before. Bird-Heilgers is alive to the problems of a growing economy. The group deploys the full potential of a century's resources, technical knowledge and executive skill to increase and broaden its activities...provide employment for many more thousands...join the national drive to economic independence.

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national productivity council journal

PRODUCTIVITY volume 3 number 4

special issue on materials handling

June-
editor

YOU CAN MAKE CAPITAL OUT OF DISASTER

One evening, Thomas Edison's laboratory went up in smoke. He was 67. "Where's Mom ?" he shouted for his wife. "Go and get her! Tell her to get her friends ! They'll never see a fire like this again."....At 5.30 the next morning, with the fire barely under control, he called his employees together and announced, "We're re-building." One man was told to lease all the machine shops in the area. Another, to obtain a wrecking crane from the local railway company. *Then, almost as an after-thought,* **he added, "Oh, by the way. Anybody know where we can get some money....** *You can always make capital out of disaster....*"

This Productivity Journal

THIS SIXTH SPECIAL ISSUE OF THE NPC PRODUCTIVITY JOURNAL on materials handling marks somewhat of a departure from the practice (adopted since June 1961) of devoting each issue of the Journal to the exposition of a single Productivity Technique. NPC has so far published special issues on Incentives, Personnel Management, Measurement of Productivity, Work Study and Quality Control.[1] These have contained, besides a number of special original contributions from Indian and foreign productivity experts, a sort of digest of the best literature on the subject, both technical and non-technical, supplemented by a large variety of case data relating to Indian industry, as also of the industry of advanced countries. These special issues have been on the whole well received both in India and abroad, which probably is a consideration for continuity of the policy decision taken in mid-1961. There has however been a demand in certain quarters for a resumption of the general[2] multi-purpose issues with which this Journal began in the autumn of 1959. The concensus of opinion however is that the productivity movement has reached a stage where, on the contrary, *a deeper and more intensive treatment of technological and economic problems* involved in the application of productivity techniques should be undertaken.

THE EGG OR THE CHICKEN

This special issue on Materials Handling is in line with this direction of thought. We have this time taken not one whole technique but part of a technique for intensive treatment. Actually, materials handling is part of the broader problem of plant layout. That point of view has been kept in mind, without wasting time on the fruitless—*egg or the chicken first*—controversy : whether the requirements of materials handling should determine

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[1] With the publication of these special issues, the significance of bi-monthly periodicity of the Journal has diminished. While every attempt is being made to publish the Journal once in two months, the processing of these special issues is such a heavy job that a somewhat longer interval than two months elapses before readers get their copies. In any case subscribers on an annual or longer basis will get six issues for each annual subscription.

[2] It has now been decided that nearly half the space in the journal will be devoted to the general aspects of productivity catering to the interests of different categories of readers. In the meanwhile, a new feature is sought to be introduced : a sort of a column on *Questions and Answers on Industrial Productivity*. This appears under the title 'NPC Question and Answer Service' on page 670.

plant layout or that the requirements of plant layout should determine the flow of materials at one end and the outflow of finished products at the other.

ON THE MOVE THROUGH

This in fact is the whole of the industrial process ~~which~~ when looked at closely in its physical aspects is *nothing but a series of steps in materials handling.* Of course, plant layout must also serve the broader social purpose of a place where vital community work is being carried on—that is the modern concept of industry—where human beings work not only for a living but to derive joy from working alongside fellow workers. These are broader social objectives. But the precise economic objective of plant layout is certainly subservient to materials handling.

From the productivity point of view there is no area that offers greater scope for cost reduction : greater scope for avoidance of unnecessary and wasteful costs that are being incurred in millions and billions of criss-cross movements through processing, storing, de-storing, packing, unpacking of materials that ought to be *on the move through* to the ultimate consumer.

THE FORD MOTOR BELT

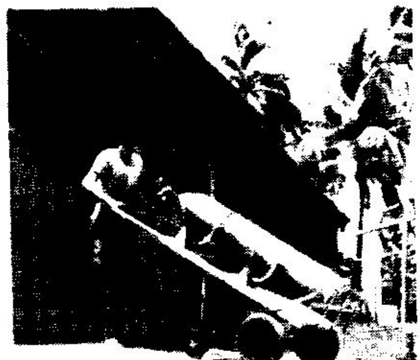
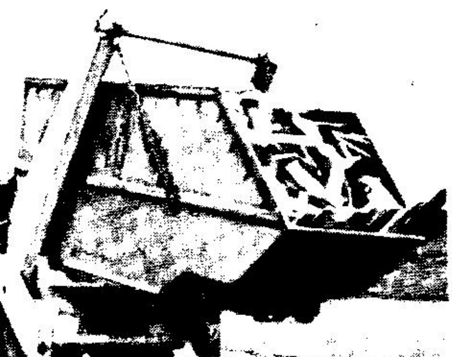
Probably the whole thing could be put in a better perspective if materials handling is analysed as part of the various processes that converge to make what is called the industrial revolution. In the pre-industrial revolution societies, the worker owned most of his instruments of production, bought and brought his materials, did all of the handling from one stage to another and then handed over the goods to the merchants. The first stage of the industrial revolution was that only the processing part was mechanised, but not materials handling as we call it now. New industries came up on open spaces; the factory owners bought materials according to market and transport conditions and *just dumped them all over the place.* The workers who were hired for processing, really spent a large part of the time in materials handling. This system had two diseconomies : one, that part of the industrial process was mechanised but a very large part of that which was involved in materials handling was still manual or non-mechanised. That is the reason why *the Ford Motor conveyor belt is rightly regarded as almost a second industrial revolution.*

THE UNKNOWN QUANTITY

The second associated diseconomy was that the worker who had been hired for processing, spent a large part of his time on actual materials handling. This meant *a very serious violation of the basic canon of productivity* which is






that a man hired for a particular job *should work face-down* on that job, and should for all other ancillary work be helped, by way of bringing materials to the point where he is processing them and taking them away as soon as the process is finished. Mechanisation of materials handling therefore would release the shop floor worker for concentration on the production process and this might mean a phenomenal increase in productivity, for the estimate in several lines is that as much a part of working time as 50 to 80 percent is spent by the worker not on processing but on handling materials in establishments where materials handling is not mechanised. The fact of the matter is that materials handling is *the very large unknown quantity in the productivity equation* which by all accounts is likely to have a substantial value for the productivity expert.

NOT ON THE SWINGS

This area has not received the attention that it deserves because the industrial engineer concerned primarily with the machine and secondarily with the man working on the machine, has had insufficient time and energy to devote to the materials handling aspect of the industrial problem. Till recently—even in the American economy in the pre-Ford era—materials handling was generally classed as the *'etc etc' of the industrial process.* It is only now that it is being realised that this area is extremely important, even quantitatively. Even highly mechanised and competitive firms are coming to realise that *the gains of productivity now lie not on the swings but on the roundabouts.* In a country like India wasteful methods of materials handling constitute a huge sink into which a large part of the industrial costs are being drawn.

PUERILE USE OF MANPOWER

Of course, in this country this problem like many other technological and economic problems gets bogged into the fundamental issues concerned with overpopulation and unemployment. If we mechanise materials handling, earth movement and the like, it will mean increase in unemployment on a fairly large scale, for a large mass of the Indian people are engaged in one form or another on materials handling. Of course, quite a number of other social and psychological issues are involved, for as the leader of the advanced management team remarked that the way that materials were handled in Indian factories was the most *puerile* use of manpower that he had witnessed. Probably it is not always so but this statement is not without its truth, for in the streets of urban and semi-urban areas it is a frequent sight to see huge cart-loads of heavy material being dragged by man or animal power. There can be no question that where human dignity or health is involved, materials handling must be mechanised. It is a matter of the utmost social urgency in order to attain the minimum levels of decency in a society patterned on the socialist model that *the headload must give place to at least the wheeled trolley*; that the huge tonnages of steel being carried on human shoulders or heads is certainly a puerile use of manpower, neither economical nor humane. At the same time we cannot allow sentiment to get the better of reason, for employment is by far the most serious social and economic problem that faces the Indian community.

EMPLOYMENT POTENTIAL

It is, however, surprising, when one comes to think of it, what a *huge employment potential the manufacture of materials-handling equipment contains within itself and by itself.* We have hardly any industry in this country manufacturing the simplest type of materials-handling equipment apart from a few isolated firms. Even at the end of the Third Five-Year Plan the total value of the materials-handling equipment manufactured in the country will hardly be a drop in the ocean of the Indian economy. It is therefore just commonsense to assert that if we proceed wisely in a planned coordinated way the aggregate employment created through the manufacture of materials-handling equipment of all kinds will far exceed the unemployment involved, apart from the great gain in human satisfaction, for the greatest and the most powerful disincentive to work in Indian society is the coexistence simultaneously of a few persons who live and work and move about in the utmost luxury while the general mass of the people plod along, carrying huge loads of various sizes and magnitudes. It is within the limits of modern technology to make work a dignified, pleasant and relatively non-fatiguing proposition. *Technology means productivity in this very vital sense of the word.*

WHOLE NEW INDUSTRIES

The main point, however, is that a modern programme of materials handling might well mean *a whole set of new industries coming into being.* We have, for example, not a single firm manufacturing complete ropeways. Then we require immediately on the largest possible scale: shovels, draglines, crawlers, tractors, motorised scrapers, dumpers, not to mention conveyors, cranes, transport equipment of all kinds. This could mean substantial employment for millions of people instead of slipshod, donkey work which would get us nowhere near the targets of industrial accomplishment, we have in view. The new Industrial Revolution would mean scales of output and employment, never dreamt of in the economic history of India.

NON-PRODUCTIVITY OF MATERIALS HANDLING

It has been argued that materials handling is not productive and that therefore it ought to be eliminated. Taken in a broad sense it is true. But the engineering argument relating to the *non-productivity of materials handling* really involves quite a number of fallacies. What it really means is that materials as far as possible should not be manually handled and that there should be a smooth, even, scheduled flow of materials from one end of the plant to the other, that *the plant layout design must have this idea of materials movement built into it.* It cannot possibly mean that there be no materials handling; nor can materials handling be described in any valid sense of the word as unproductive, for materials have necessarily to be moved from the place of their original output to the points of ultimate consumption; and they have necessarily to be transported, handled and processed. It, of course, goes without saying that as direct a movement of materials from the place of origin to the place of ultimate consumption is the most productive; for without such movement and handling the commodity does not attain its ultimate stage of productivity, that is satisfaction to the consumer. Materials handling covers two out of the three fundamental Aristotelian categories regarding production: the utility of form, the utility of place and the utility of time. A system of materials handling moves things to places of greater utility and at a time when this greater utility can fructify. Of course it need not be added that *the system in itself must be the most economical considering* all the circumstances of the case.

THE SPECTRE OF AUTOMATION

In this context the spectre of automation has been held forward as a sort of threat to the future of industrial society. This hardly makes any sense. Complete automation does not mean complete unemployment; on the contrary, it means in a well-organised community the accomplishment of industrial tasks with a lot more of leisure associated with it. It means that on the average an individual worker may have to work for much less time. The important part of the automation process is a considerable increase in the level of skills necessary for the accomplishment of tasks. The automated plant in which materials are not only handled mechanically but the handling and processing of materials proceed mechanically in a rythmic sequence means in fact more planning, more work done on automation itself, on the processing of the automated plant. Of course the process can be pushed backwards and forwards, *ad infinitum.* It would mark the *ne plus ultra of economic change.* It certainly will not make unemployment. It would really mean a revolutionary change in cultural values.

~~KEEP IT MOVING~~

The American experience which is probably the richest in the line has in it certain elementary lessons which we in this country have to learn.

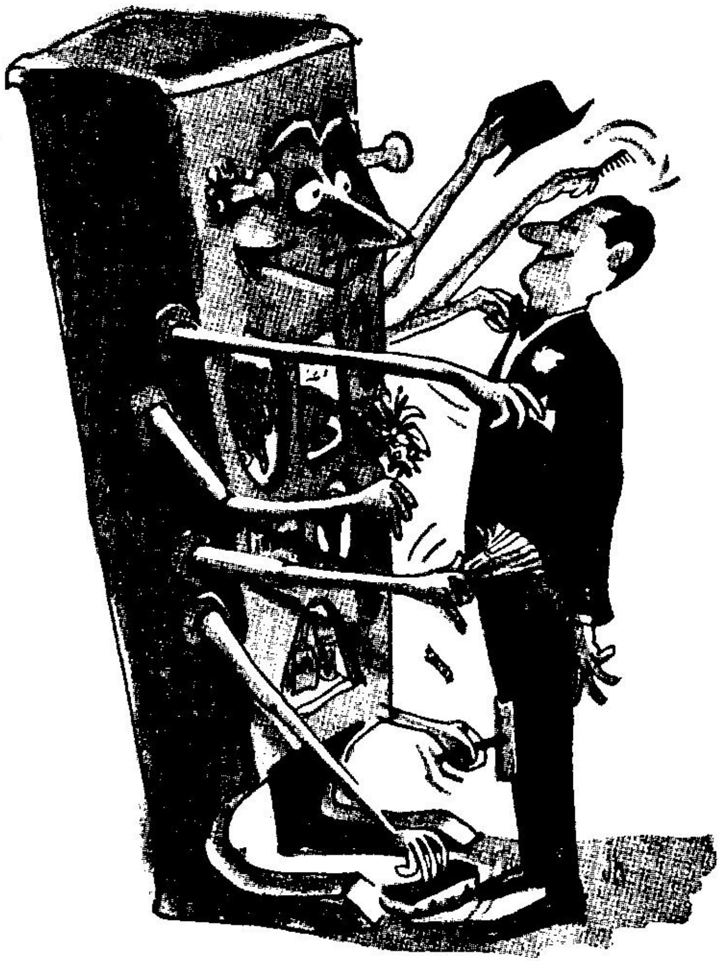
For instance, American industry considers it uneconomical that materials be placed on the floor, for this involves three costs, for not only have materials to be placed on the floor at one point and placed at the floor at another point but someone has to be paid every time to pick it up. Materials Handling therefore also involves attention to placement. And this leads us on to inventory control, for materials are moved to points, stocked and moved on again. In fact the whole of the industrial process can be broken up into three categories: movement, placement, processing, in a chain as it were; for processing is again followed by movement and placement, further processing, further movement, placement again and so on. It would be truer to say that it is not materials handling that is unproductive but placement or storage; for while things are placed or stored, costs are incurred, apart from depreciation and market fluctuations. But as in all human affairs, certain costs have to be balanced against certain other costs, for if we have got the machines and we have hired the men but materials are not available because they have not been stored, the firm incurs costs to which no incomes correspond. In any organisation of human affairs there are certain inevitabilities, certain disharmonies, certain risks involved and some margins always to be covered. Production planning and scheduling inevitably involve some amount of inventories on either side of the production line: materials in process, stocks and finished products. While therefore '*keep it moving*' *is a good productivity slogan*, it would take quite a long time to achieve that idea at least in the Indian economy.

WORK STUDY AND MATERIALS HANDLING

We have for instance to make a work study of the jobs that we undertake; and we must know that work study is particularly useful at the planning stage. The whole layout pattern must be based on work study which in turn, apart from human and social considerations already alluded to, must be based primarily on the requirements of materials handling. Further, work study must include work measurement. So far work measurement or time study has been limited to what is called the production process or direct work. Indirect work or materials handling has by and large not been covered by work measurement. Since a large part of the time—in many cases more than 50 percent—is spent on materials handling work, measurement is likely to yield pretty high dividends in this more or less uncovered area.

OPERATIONS RESEARCH

It is obvious from the above analysis that it is only an integrated application of several productivity techniques—materials handling, plant layout, work study, inventory control and all that—that can effect a large increase in productivity. Mere materials handling by itself without other accompanying techniques will not lead us to the optimum levels of productivity. A large part of the work that has been done in the field of productivity in the post-war period points to this conclusion that overall emphasis should be laid on such integrated techniques as production planning, operations research involving the use of a number of disciplines converging to accomplish *a simultaneous and substantial increase in worker satisfaction, welfare and productivity.*



AUTOMATION

Choice of Technology

JAN TINBERGEN

Mechanised materials handling being the ultimate limit in the application of modern technology to industry we in India have to seriously consider the issues involved in the context of our peculiar resource endowment, namely, plentiful and rapidly growing supply of manpower alongside shortage and growing scarcity of capital resources in the context of an ambitious development programme. In the United Nation's publication on Industrialisation and Productivity the famous economist Jan Tinbergen had discussed the fundamental question of the Choice of Technology in Industrial Planning*. The basic judgement Jan Tinbergen arrived at as a result of a pretty acute analysis was *that such a choice in technology exists*; and that in fact research in underdeveloped countries ought to be so directed as to accomplish a reorientation of technology along lines dictated imperatively by their own labour capital ratios which are in sharp contrast to the conditions under which the Western democracies accomplished their industrial revolution. The fundamentals of the position as arrived at by Jan Tinbergen have been run together in a foot-note printed at the end of this article for the benefit of those who would like to pursue this interesting and significant subject of such importance to economic planning in this country. Here in this short article extracts have been printed which relate to materials handling.

A REPORT OF THE UNITED STATES Department of Agriculture[1] describes six methods of materials handling, designated respectively by *A,B,C,D,E,* and *F,* and gives the labour and equipment costs corresponding to each technique (*see* table 1 and chart). It will be noted that, paradoxically, some of the methods require not only more capital but also more labour than others. Thus, methods *A,B,C* and *E* require both more labour and more capital than method *F*, while *A* also requires more of both than *D*. Clearly, the implication is that, at any price of labour and capital, *A,B,C* and *E* will be more expensive than *F*; and *D* will always be cheaper than *A*. Points on chart corresponding to techniques (or combinations of factors) which are, at any factor price, more expensive than other techniques, may be called "inefficient" points. Of the six points in the diagram, four *A,B,C,E*—

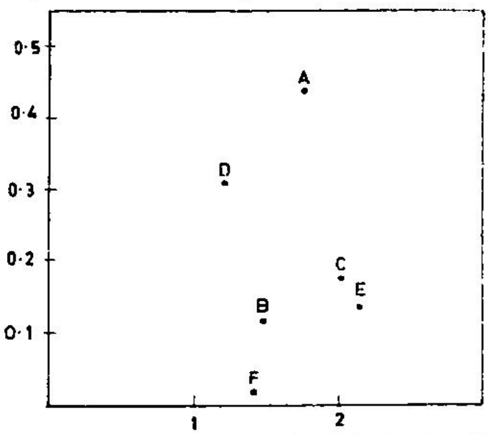


Chart Isoquant diagram for six methods of loading delivery trucks capital.

are inefficient, while only points *D* and *F* represent effective alternatives where *D* requires more capital and less labour than

* NPC PRODUCTIVITY Journal, volume 1, number 2, page 50.

1 "An Analysis of Some Methods of Loading Delivery Trucks of Produce Wholesalers", *Marketing Research Report, No. 15* (Washington, D.C.).

Table 1. Data on six methods of loading delivery trucks of produce wholesalers (dollars per ton loaded)

METHOD	COST OF LOADING ONE TON	
	labour	*equipment*
A. low-lift platform trucks and dead skids for assembling and belt conveyors for loading	1.74	0.44
B. two-wheel hand trucks, semi-live skids and jacks for assembly, belt conveyors for loading	1.46	0.12
C. semi-live skids and jacks for assembly and elevating and horizontal belt conveyors for loading	2.02	0.18
D. fork-lift trucks and pallets for assembly, belt conveyors for loading	1.19	0.31
E. four-wheel hand trucks, fork-lift trucks and pallets for assembly, gravity conveyors and manual handling for loading	2.13	0.14
F. four-wheel hand trucks for both assembly and loading	1.41	0.02

F, and vice versa. For certain relative labour capital prices, especially for relatively high labour costs, *D* may be cheaper than *F*, while for other price ratios *F* will be cheaper. The inefficient points may correspond to techniques in use before some of the other combinations were available. Some of these methods may still be preferable in cases where they offer some special advantages (for instance, speed or flexibility).

A case study made by the Eastman Kodak Company on costs in materials handling may be mentioned.[2] The study gives figures on annual labour costs and required capital imvestment for three different methods of shipping the company's products, based on an analysis of cost data. The results are summarized in table 2.

Table 2. Annual Labour Costs and Capital Investment for Three Alternative Methods of Shipping Eastman Kodak Products (Thousands of dollars)

METHOD	LABOUR COST	CAPITAL INVESTMENT
A. tractor train	57.6	69.4
B. dragline conveyor	54.8	77.3
C. combination of A and B	43.4	92.6

According to these and other figures given in the study, the combined use of tractor train and dragline conveyor is the cheapest method of operation under labour and capital cost conditions prevailing in the United States. As table 2 shows, this conclusion does not necessarily apply under conditions of lower wage or higher interest rates, or both.

The operation of many industrial processes involves a certain number of subsidiary activities in addition to the production process proper, such as materials handling ("internal transportation"), packaging, shipping and administrative activities. Such operations can be undertaken by way of a wide variety of methods, ranging from very labour-intensive to highly capital-intensive. It is a common experience of those who have visited plants and offices in underdeveloped countries to discover that there are, in comparison with developed countries, much larger number of people engaged—and not always continuously—in transporting materials, documents or messages. It is often this "surplus" manpower rather than labour engaged in production proper that accounts for the higher labour-product ratio observed there. As is well known, some of these activities, in particular materials handling and administrative operations, have undergone during the last decades a process of extensive mechanization in most industrial countries, though even there it has not been by any means a general development. Such changes were justified by the rise in wage levels, even though examples may be given where, on closer examination, mechanized

2 RC Bryant, SA Wahl and RD Willits, "Tractor Train or Dragline Conveyor?" *Modern Materials Handling* (Boston, Massachusetts).

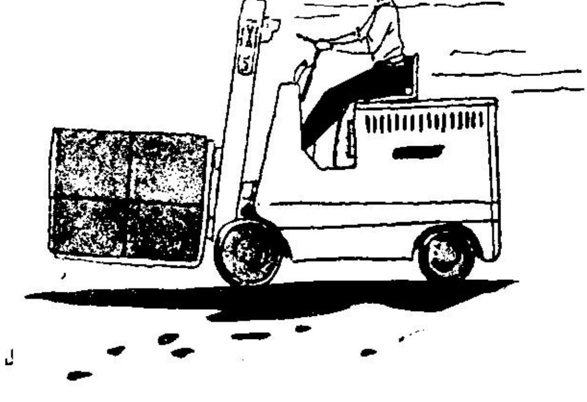
devices did not appear to result in lower costs; this was so, in particular, where the scale of operations was not sufficiently large or the operations not sufficiently uniform.

There are a few activities, not typically industrial, where large divergencies in capital intensity appear to prevail. Transportation, taking the term in its widest sense, is one of them. Between the use of head baskets by Chinese or Indian workers and use of heavy trucks, there is a wide range of intermediary methods and combinations of methods involving use of numerous types of light or of heavier vehicles, moved by hand or drawn by animals, or by mechanical power. Even a railway system may be operated in widely different ways, as is shown by a statistical comparison of the operation of American and Indian railways. Here again, it is probably in the auxiliary operations such as loading and unloading, passenger service and administration, that the greatest variations in capital intensity can be found.[3]

3 To give another example, the capital intensity of an underground railway system will be considerably higher than that of any system of surface transportation.

* * *

Very often, neither planning authorities nor engineering experts have seemed to be aware that the problem of choice exists for a large number of industrial activities. . .The development of technology—so far largely influenced by the particular conditions of the industrially advanced countries of the West—has been characterized by the growth of capital-intensive, labour-saving processes, in line with the evolution in these countries of the relative prices of capital and labour, which has been favourable to such a development. There are now good reasons to reconsider realistically the technological problems involved in the industrial development of underdeveloped countries in the light of the endowment in factors which generally prevails in these areas. . .Excessive mechanisation has also at time been introduced in industry in underdeveloped countries in order to avoid "the trouble of dealing with people", that is, to avoid the occurrence of human errors, and to lessen the effects of labour turnover, burdensome and irksome labour legislation, strikes, and so on. When pushed too far, such practices have had consequences contrary to the basic interests of the national economies concerned. The *economic system should be run in the interest of all citizens*. . .The basic technological data concerning each industry are, in the last analysis, the relative quantities of the factors of production. The theoretical answer to the question of what technology to select is given by the relative prices of labour and capital in the country concerned. . .Leaving aside the technicalities which depend on the goals of economic policy in each country, the essence of *planning should be that all industries taken as a whole employ as nearly as possible the entire capital stock and the entire labour force. To leave part of these resources idle would result in a waste of resources and less than optimum level of production.*



Elements of Materials Handlin

IN RECENT YEARS MATERIALS HANDLING HAS become a specialist subject in which the rate of technical development is ever-increasing: new ideas, new types of equipment, and new applications of known principles, are made known almost every week. No firm, big or small, can afford to be ignorant of progress in materials handling. Yet, except where there is a responsible executive, materials handling is commonly disregarded. The chief executive and his departmental managers, intensively concerned with the processes of their industry and with the routine of their tasks, have little time to spare for the study of their materials handling problems, and there is nobody to remind them of this vital element of productive efficiency.

There are, however, many firms in this country which have appointed materials handling engineers, and not all of these firms are either very large or engaged principally in quantity production. Firms which have appointed an executive to be responsible for materials handling throughout the works have obtained much benefit and, often, valuable economies. The appointment of a materials handling engineer indicates clearly a recognition by the higher management of the importance of materials handling in the production process and gives notice of that recognition to all departments; it also offers the person chosen for the post an opportunity to keep abreast of progress and to become his firm's authority on the subject.

But the appointment of a materials-handling engineer does not solve all the problems.

*From the British Institute of Production Engineers' publication.

Those responsible for factory siting of plant: methods engineers; of special-purpose machines and jigs and fixtures; and last (but by least) designers of the products must also realise the importance materials handing in low-cost p and all these specialists must ha knowledge of the basic principles handling practice.

Too many executives in British still think that all needed to handling efficiency in their fac purchase of more equipment, more power trucks, overhead runwa but there are many factories wi mechanical equipment in which handling efficiency is still low. Good handling is not the presence of suitable equı also dependent on a proper atti

The Production Engineer with training in the principles of ma ling, tackles a handling problem the question, posed in a Governmen poster, "*Is your journey really necess* other words, the engineer starts by the cause and purpose of the This sounds too obvious to be distinct stage, but it is surprising these searching examinations en discovery that certain movements necessary and can be eliminated As an example, it is frequently economical to move workers and to the product-in-process, than to product to the normal workin without a critical analysis of of movements this fact may never apparent.

The second question the Production Engineer asks himself is almost as commonplace as the first one: "Is it necessary to move the material all this distance?". An answer to this question requires an examination of the surrounding layout, and the examination often produces surprising results. Correct reseting of connected operations has often solved complex materials-handling problems by eliminating the need for moving the materials at all. Much unnecessary transportation has been avoided by remembering that the shortest distance between two points is a straight line—even if adherence to this principle involves knocking a hole in a wall rather than using existing doors, or knocking a hole in a floor rather than using existing stairs.

Then the Production Engineer considers: "How can I make the best possible use of natural resources in solving my handling problem?". The most important natural resource is gravity. A simple materials handling installation based principally on the use of gravity is often as effective as an expensive power-driven conveyor system. Another natural and frequently neglected resource may be in the shape of the article to be moved; this is obviously the case for those articles the shape of which permits them to be rolled. *The idea that mechanisation is synonymous with progress is erroneous,* but at the same time it is important to realise that nothing should be picked up twice that can very well be handled only once.

There should be *no prior preference for particular types of aids* to movement of materials; instead, the best way must be sought of handling a particular product. The best way will depend on the peculiarities of that product, i.e., its size and batch quantities; the geography, including head room, of the shop in which it is processed; storage facilities and the processing or handling that follow in other departments. It may be that a standard type of bin or container will handle the work successfully through the entire plant; standardisation of equipment is certainly an important matter. *The Production Engineer need not look to expensive equipment to overcome his problems*; frequently, even in the smallest shop or section, many out-moded methods can be abandoned and *innovations made at very small capital cost.*

At this point the Production Engineer might say: "How can the product be passed to the next stage without anyone having to fetch it?". A possible answer might be found in the use of a container on simple roller gravity conveyors.

It is important to realise that, although a problem may seem to require other than standard equipment, it is quite probable that there is already another plant with completely suitable equipment in use. Hence it is important that all engineers responsible for handling installations should secure access to the continuous exchange of experience on handling problems.

It is only after the materials handling engineer has asked and answered questions similar to those given in the preceding paragraphs, that he should proceed to the mechanics of a particular materials-handling problem. The correct analysis of conditions is an essential preliminary and may, indeed, constitute more than half of the entire task.

Some mischievous boys glued together the pages of the minister's large Bible. When the parson started to read the lesson from the scriptures, he read at the bottom of one page, "When Noah was 120 years old, he took unto himself a wife who was"—and then he turned the page—"140 cubits long, 40 cubits wide, built of gopher wood, and covered with pitch inside and out."

No More Frontiers!

WILBUR G HUDSON

THE STUDENT OF ENGINEERING APPROACHING THIS ART may get the impression that it has reached its limitations—that there are no more frontiers. Scanning the catalogues of thirty years ago we see the same types of elevators, flight conveyers, skip hoists, belt conveyers, crushers, etc., as are illustrated today. Actually, great progress has been made, and more is to come. The introduction of V-belts and high speed drive chains, alloy steels, hydraulic and pneumatic conveyers, vibrating screens and feeders, motorized reducers, powders, sealed anti-friction bearings, improved conveyer belts and rolls, *en masse* conveyers, and automatic controls create new possibilities in efficiency, long life, and reduced costs of handling. Certainly we have no reason to think that we have now reached the limits of development in this important field of engineering.

A Walk Through Your Plant

Y Brymldsser

Let's take a walk through your plant. In the receiving department : Are any materials unloaded by hand ? . . . Are materials standing around—piled up in the yard or on the receiving platform—waiting to be moved into the plant ? . . . How long have they been there ? . . . How frequently does this occur ? . . . Do men stand around idle a good deal of the time, waiting for material ? . . . Would it be cheaper in the long run to buy such equipment as car-dumpers and portable conveyers to eliminate the need for extra men ? . . . Are materials unloaded in the yard, stacked, then moved to a receiving platform before finally moving into the plant ?

In production areas : Do skilled workers handle materials or heavy dies ? . . . Is the production area cluttered with parts and materials waiting to be used—or to be moved to the next operation or discarded ? That not only interferes with production, but also invites damage. 'Live storage' conveyers and tiering trays can do a lot to relieve the situation. Better scheduling of materials handling can help, too . . . Is every part, pallet load or tote box clearly (and permanently) labelled with tags that show where they have come from and where they are going; to what order they apply; and what special handling is required ? That will prevent losses, misdelivery, extra handling . . . If you have a multistorey plant, and elevators are used to move materials between floors, how long do materials handlers have to wait for an elevator ? Multiply that figure by 20 or 50 times a day the materials handlers use the elevator, and you'll see how much time is being wasted . . . How are materials moved from one machine to another, and how are they lifted to working level ? If your production area is not sprinkled with small chutes, conveyers, lifting devices, and the like, you're probably losing an opportunity to speed production and cut costs.

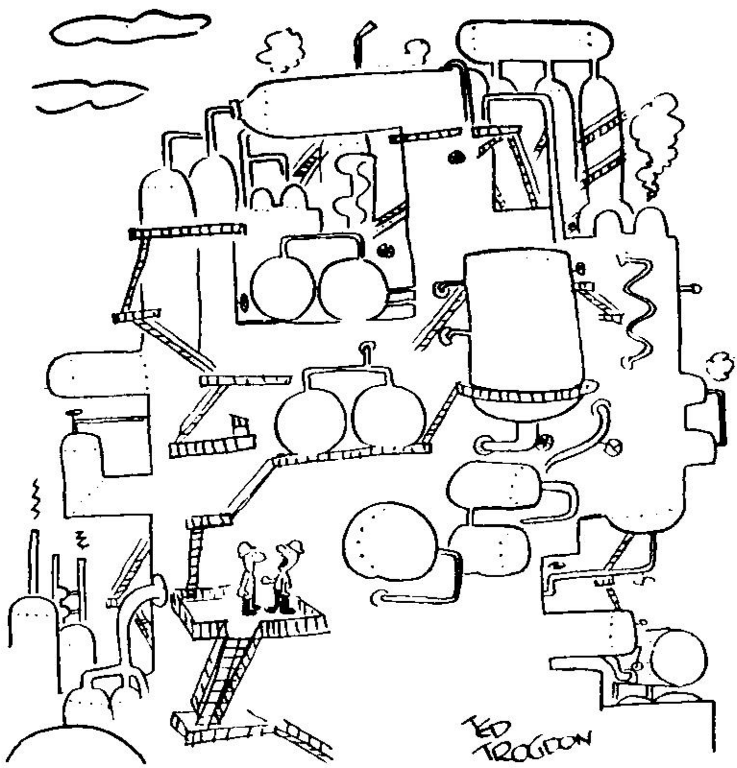
Is scrap disposed of mechanically—with conveyers taking it right from the source to storage bins? That can not only save handling costs, but can also safeguard segregation procedures—and bring you a greater return on scrap sales . . . Are aisles clear, smoothly paved, and well-lighted so that traffic can flow freely and safely ?

In storage areas : Are storage areas well-lighted to permit rapid movement of equipment and easy reading of identification information ? Good lighting is just as important here as in production areas . . . Are storage areas marked off into sections, and are these sections numbered or lettered for identification ? . . . Is a record kept of what is stored in each area, so that parts and products can be located rapidly ? . . . Are floor and ceiling load-limits prominently displayed, so that floors and ceiling-mounted conveyers are not overloaded ? . . . Are products stored in the most-easily handled form; and in units in which they will be shipped ? If, for example, orders generally call for a dozen items, are they packed and stored by the dozen ? . . . Is full use made of overhead space by stacking pallets three and four high, such as, for example, by using racks that go up to the height reached by materials-handling equipment? . . Has traffic movement in storage areas been studied to work out the shortest routes; are items which are generally used or called for together placed in areas next to each other ? . . . Are aisles wide enough to permit free movement of handling equipment ? . . . Is the floor kept in full repair at all times ? . . .

Are storage areas located as close as possible to the production areas they serve? Establishing small 'branch' storage areas for in-process parts can save a good many miles of travel in a year—and more than pay for any extra cost involved in establishing them.

In the shipping department: How are parts moved from storage to shipping? ... Would installation of conveyers or use of power trucks speed and simplify the job?... Are outgoing products ready when trucks and railroad cars arrive—but not ready so far in advance that they run the risk of or deterioration?... Is the shipping cluttered with products and packages to be moved? That's a sure sign some wrong, and a strong hint that planning scheduling need close attention... Is package clearly labelled as to destin and mode of shipment?

Are portable conveyers or mobile in vehicles used to load freight cars and ...Are men standing around wai something to do—or working their hear trying to meet an unexpected deadli



"Funny that we've both worked here for twelve years and this is the first time we've met."

Thinking Ahead on Layout

In the *ideal* plant, raw materials would enter at one end, go through the various processing steps in order, and emerge at the other end—without any backtracking or side trips. Obviously, this is not possible in most plants. It could be achieved only by a company which produced a single type of product, and which could start from the ground up, to build a one-storey tunnel-type plant. For most companies, actual plant layout represents a compromise between this ideal, and the hard facts of space available, location of departments which cannot be moved, and the processing needs of a variety of items.

PRACTICALLY EVERY COMPANY WILL FIND worthwhile opportunities to reduce handling costs by studying layout and processing sequences and by rearranging the ground plant to achieve minimum total travel for each part and material. In addition, it's possible to speed the flow of materials, reduce accident hazards, and eliminate handling bottlenecks. And, in planning a new plant, it's possible to avoid *built-in* handling costs by considering layout long before construction starts. Future headaches can be eased by making the new plant as flexible as possible from the handling point of view. In other words, plan the plant not only for the processing system you now expect to use, but also for possible future changes.

Perhaps it seems—at this time—a good idea to sink the aisles an inch or so below floor level. But, if you do, it will be mighty expensive to change aisle locations as manufacturing plans change—or to buy wider industrial trucks.

If you're planning a new multistorey plant to process bulk material—flour, for instance—you'll want to provide for holes going through the floors to allow passage of chutes and tubes. But you'll be twice as smart if you have bracing members arranged in such a way that new holes can be put through at almost any spot you may desire in the future. Otherwise if you later move equipment and cut new holes, you may seriously weaken the floor.

If your plant is already built, there is not much you can do about location or girders or of certain special equipment, but you will still want to *keep next year's needs in mind when planning tomorrow's changes*. Perhaps it might be better to spend a little more for portable, rather than fixed conveyers so that when methods change, you'll be able to rearrange the conveyers easily. Or perhaps you had better think twice about putting that hole through the north wing's ceiling. May be you'll want to use the second storey for storage later on—and won't be able to because the floor has been weakened too much.

Naturally, there are occasions when permanent installations should be made. But they should be studied from all angles before actual installation starts. It's often worth paying a premium—in actual money or in a slightly-less-than-perfect setup—to keep your layout flexible and ready for future changes.

planning spatial relationships

What steps should you take in finding the best possible compromise between the space you have available and the *ideal* layout? The first step is the same whether you are planning a new plant or rearranging an old one:—Without reference to present physical layout, make up a process or flow chart, listing the operations involved in making *each* of your products. Start with the delivery of the raw material, and carry the list right through to final shipping. In addition to noting operations, it's important to indicate the approximate *amount* of material that must be moved—per hour, day, or week, and the frequency of movement.

Now, if you were planning a new plant and expected to make only a single item, you could simply draw a map of your floor space, and set the operations down one after another in proper sequence, starting at one end of the plant and finishing at the other. You would, of course, have to decide how much space should be allotted to each operation, and consider other factors like aisle width.

Unfortunately, few companies are in that enviable position. Most companies make more than one part or product, and most have a far-from-ideal physical plant in which to work. Plant layout then becomes a process of compromise, keeping in mind not only materials-handling problems, but also such questions as lighting, location of plant services, necessities of supervision, and so on.

Often, materials-handling problems can be simplified by combining process improvement with plant rearrangement. Suppose, for instance, you produce a part that must be heat-treated twice during fabrication, and that at present moves from a production area to the heat-treating department on two occasions. One way to hold handling to a minimum might be to place the heat-treating department midway between the two production departments. If, however, travel between the first production operation and heat-treating is considerably longer overall, than travel between the second production operation and heat-treating, the most practicable solution might well be to locate the heat-treating department right next to the first production operation, and leave a greater distance on the less-travelled route.

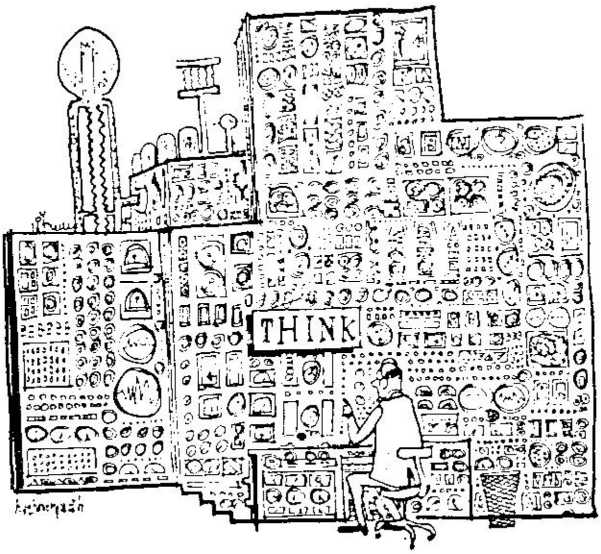
That's one type of solution, but there are, of course, several others. It might be possible, for instance, by redesigning the part, to eliminate one or both heat treatments. It might also be possible to simplify handling by installing as induction or flame heater right on the production line. Every possible solution should be considered before a final decision is made.

Thus, the process of study, measurement, and compromise goes on. By rearranging the plant layout, it would be possible to reduce handling a good deal. When, at the same time, unnecessary cleaning and inspections are eliminated, and the remaining bench work and inspections are performed at departmental stations, rather than in a separate area, the number of operations and the distance of travel are greatly reduced. Though this is an *armchair* example, it shows the methods used, and the savings which can be achieved when layout, handling, and production methods are studied as a whole.

other factors

Spatial location is only one of the factors to be considered in planning plant layout to reduce materials-handling costs. Another—and a very important—consideration is the type of handling equipment that is to be used. It works both ways: the type of equipment affects the layout; and the layout affects the type of equipment that is chosen. Obviously, *fork trucks can't climb stairs and cranes won't hang from skyhooks*. But there are other, less obvious, factors to consider. If, for example, fork trucks are to be used, it is good to have aisles wide enough to permit easy passage of two fully loaded trucks, without danger of bumping. Crossroads should be avoided so far as possible (a circular road around the outside of the plant or midway between the centre and the walls is good, provided it is practical from other points of view). Where aisles cross, it's important to make sure there is good visibility in both directions for truck operators on both roads. Blind intersections are extremely hazardous. Therefore, it is not a good idea to locate a large, bulky machine at the corner of such an intersection. Doors, too, must be wide enough to accommodate fully loaded trucks, and provision of a separate pedestrian exit is a good safety precaution. Lighting above aisles rates special consideration. Even if no machine work is performed along aisles, a rather high level of lighting is required for safe truck operation. Floors, too, should be checked for smoothness, as well as for ability to stand constant travel by fully loaded trucks.

Thus, a plant layout that does not consider materials-handling problems is likely to be unsatisfactory. *But when handling and layout are planned together, real savings can be achieved.* A manufacturer of fractional horsepower motors, for instance, cut travel in assembly alone from 14 miles to 9 by revising layout of the assembly department. The mileage figures represent the total distance travelled by all the parts making up a single motor as they went from one work bench and inspection station to another. Parts may move only a few feet at a time, but the distances may add up to a staggering total, as this example shows. In a metal working plant, better layout so improved handling efficiency that overtime—which previously accounted for 30 percent of labour costs—was eliminated entirely. In a plastics plant, product damage dropped to a fraction of its former costs when layout was simplified and handling reduced. Now miracles in productivity can only be achieved *via* Materials Handling.



Layout and Handling*

The subject of Materials Handling is considered so important that some firms have appointed a full-time engineer to study methods already in use and make recommendations for their improvement.

LAYOUT AND MATERIALS HANDLING ARE closely linked and are an integral part of Method Study. A careful arrangement of workplaces, equipment, and stores eliminates unnecessary handling and so reduces costs and increases productivity.

The ideal arrangement is for the raw material to come in at one end of the building, pass through all the manufacturing processes, and emerge as the finished product ready for despatch at the other end. Where transport facilities are available on one side of the works only, or where the building does not allow of straight-line flow, an alternative arrangement is for raw material to come in at one door, go through the various processes of manufacture, and leave the factory as a finished product by the same door.

The modern trend is towards the single-storey building. There may, however, be advantages in multistoreyed buildings, especially if full use can be made of gravity flow between processes.

In planning the layout, a number of devices may be used which save time and make the comparison of alternative schemes easier. For example, cardboard templates, cut to scale to represent machines and benches, can be moved round on a plan of the factory until the best positions are found. A more elaborate method is to use scale models in which overhead obstructions can be taken into account.

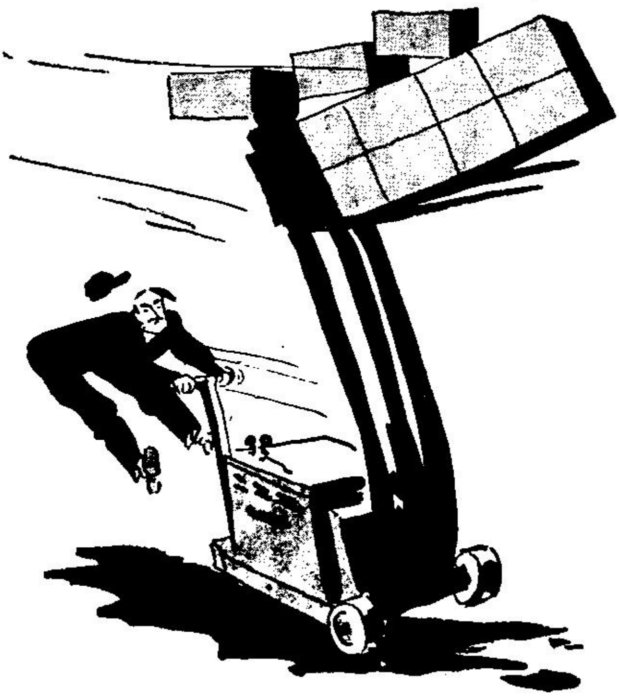
*Publication **Better Ways.**

In planning, it is advisable, wherever possible, to allow for future expansion so that new machines and processes, added from time to time may not cause the flow of work to be unnecessarily complicated. Where this state of affairs exists, a complete study of the work flow may be made. The route followed by raw materials, components and finished products may be recorded on flow diagrams, with the aid of which the best possible flow can be ascertained.

The best layout is one in which an operative can take over the work from the previous operative in line without having to move from his workplace. This is not always possible, as distance, weight of piece, or the type of machine on which the process is being carried out may call for the assistance of a handling device.

equipment

Many improvements in materials-handling methods may be made without heavy capital expenditure. Devices have often been made by firms from their own resources. Many types of equipment, including the following, are in use : (*a*) *Gravity chutes*; useful for transporting material from a higher to a lower level, are often cheap to make and require no power in their operation (*b*) *Roller conveyors* also may make use of gravity or be placed between machines so that a slight push will transfer the work to the next process; also serve a useful function as buffer stores between jobs, thus eliminating delays and helping the operative to work with a steady rhythm (*c*) *Power-driven conveyors* may vary from the simple type of belt or *slat* conveyor to an elaborate overhead type running right round the factory. In large-scale assembly work the main component may not leave the conveyor : the smaller components are fed to each workstation, where the operative affixes them to the main assembly. (*d*) *Cranes and hoists* are of many types, ranging from the small jib crane to the elaborate power hoist. Where heavy materials are used, flexibility may be maintained by providing unit hoists to each work-bench, which help to cut out waiting time, eliminate fatigue and provide maximum machine utilisation. Cranes may be fitted with special slings and other adaptors, according to the materials handled; for example, electromagnets may be used to lift steel plates (*e*) *Fork-lift and power trucks*: The fork-lift truck may be described as the *maid-of-all-work*, as it can be used in unloading, transporting materials and components round the factory. The main advantages lie in its flexibility, speed, ability to stack at reasonable heights, or transport heavy loads with minimum use of manpower (*f*) *Pallets* may vary from the simple board type to collapsible box types. Pallets enable the system of unit loading to be adopted and combined with the use of the fork-lift truck; they provide an efficient means of materials handling and storage. This is made still more effective where firms have arranged with their suppliers to send materials of bought-in parts in unit loads, thereby reducing handling and inspection costs of both buyer and seller (*g*) *Trucks, trailers and barrows*: Inside and outside the factory there are numerous devices for handling and transporting equipment, some hand-propelled, others power-driven, often adapted to meet special needs, but each contributing to the saving of time, effort and cost.



Materials Handling and Work Study*

Russel M Currie

PROCESS OPERATIONS, REFERRED TO IN WORK STUDY AS "DO" OPERATIONS, MUST BE the first to be considered because if these are changed in nature and sequence, combined or eliminated at any point, the associated handling and movement operations would at once be affected. A very simple example will illustrate the importance of this approach. Assume there are two consecutive operations performed some distance apart at points A and B, and it has been suggested that the method of handling materials from one to the other should be investigated. The questions requiring to be answered are 1) can A or B be eliminated ? 2) can A or B be combined in one operation ? 3) can A be brought next to B ? If the answer to any of these questions is "yes", then handling is not necessary.

Handling studies are carried out by means of the method study charting technique and the questioning sequence. For example, to appreciate fully the implication of these answers it may be necessary to consider such factors as 1) the form in which materials are supplied 2) the estimated utilisation of new handling equipment 3) the effect of changed methods on overall cost 4) handling methods in other departments.

Applying the questioning sequence in this manner establishes the need, place, order, person—finally the means of carrying out what the best method requires. All possibilities of falling into the error of considering handling equipment first and endeavouring to fit it into a particular situation are thereby eliminated.

The fundamental analysis of the job is carried out by applying the questioning sequence to the process chart in the appropriate way. It may be desirable, however, to supplement the process chart with other aids, such as the flow diagram, string diagram or multiple activity chart. In a materials-handling problem the paths of movement will in general be of major interest and a flow diagram may be of considerable help when dealing with the question "Where" ?

*From the author's classic book on Work Study

Mechanical Handling and Work Study

FEW PEOPLE TODAY ARE UNAWARE OF the potentialities of mechanical handling but many are unwilling or unable through lack of time, experience or forethought to apply it to its best advantage. With the intention of encouraging furniture manufacturers not only to adopt mechanical handling techniques but also to give serious thought to their strict coordination, the Furniture Development Council have recently published a valuable and stimulating report entitled 'Methods of Materials Handling in the Furniture Industry'. The most significant point that emerges and the one that receives most emphasis is that the success of materials-handling system is very largely dependent upon its coordination with a routine of work study. It becomes apparent that as a general rule the need for these two relatively new developments in industry to supplement one another is far from being fully appreciated at any rate in the furniture industry. The picture has to be seen as a whole : problems must not be considered piecemeal. Where mechanical handling aids have been adopted, without thought to the flow pattern of work, it is inevitable that what advantages have been gained will be seriously impaired both from a productive and economic point of view.

The procedure which is outlined in the final section of the report is in itself an excellent introduction to the kind of thinking that work study requires. When considered without the aid of a system of analysis, definitions and categories of work blur easily and it is only through the application of such devices as process and percentage analysis charts, machine summaries and flow process charts used, in many cases, in conjunction with models of layout, that the overall picture necessary can be brought sharply into focus.

Mechanical handling is essential to attain improved and more economical production, but without a complete and ruthless analysis of the flow pattern of work from the preparation and transport of raw materials to the works until its receipt by the customer, its application can sometimes be futile and will always represent a loss in efficiency.

"I want business to do well," President Kennedy told a White House Visitor. "If they don't, we don't."

What To Move ?

Men and *machines* combine to make *products* out of materials. The three have to be brought together. Which two do the moving and which stays put? Men and machines remain with you, but you sell the product—it ends up being taken away. So, in the end at least, the product has to be moved. But it doesn't always pay, during manufacturing, to move the product to the men and machines. Sometimes it costs less to move the men and machines instead.

WHEN YOU MAKE A SHIP, SAY THE QUEEN ELIZABETH, it is more convenient to make it in one spot and to bring men, machines, and parts to it. Factory products don't match the Queen Elizabeth in size (it weighs 84,000 tons), but many factory products are big and unwieldy enough to make it pay to move men and machines (usually portable tools) to the product. This is particularly true in assembly work where the product takes on its full size.

Airplanes, locomotives, and other large products are put together at "work areas". The areas are big enough to hold four or five products. As soon as a partially assembled locomotive arrives in position 1 in the area, a crew of men do certain work on it: usually attaching parts and assemblies. By the time they are finished, another locomotive has been put into position 2 in the area so they move over and do the same work on it. Then on to position 3 and so on.

As soon as the first crew leaves position (1) another work crew carries on the assembly from where the first crew left off. When they finish, they move on to the locomotive in position (2) following the first crew. Meanwhile a third crew takes over at station (1) and does its work. Then it moves on to station (2) and so on. By the time the first crew is done at station (5) the locomotive in position (1) has been removed (by an overhead crane or—in the case of airplanes—by a tow truck) and another fresh one to work on has been placed there.

This method reduces product handling costs and is a great saving. But don't overlook the fact that this reduction was made possible only by moving the men and their tools instead of moving the product. Moving men and tools is also costly but for large products, less costly than moving the product often.

Materials are handled at so many places in the plant that no one person can find all of the places where improvements can be made. The actual handling is done by hourly paid workers, so why not ask them how to do it better? This is what some companies do. The foremen, too, are well acquainted with the picking up and putting down and hauling of materials that their men do. Ask them too for ideas. Searching out wasteful handling and getting rid of it should be a continuous objective of everyone concerned with materials handling.

Any analysis of materials handling, whether by chart or by other methods, should show *how much* and *how often* materials are handled, *how* they are *transported*, and *how far*. The study should reveal any points of congestion that exist and their causes.

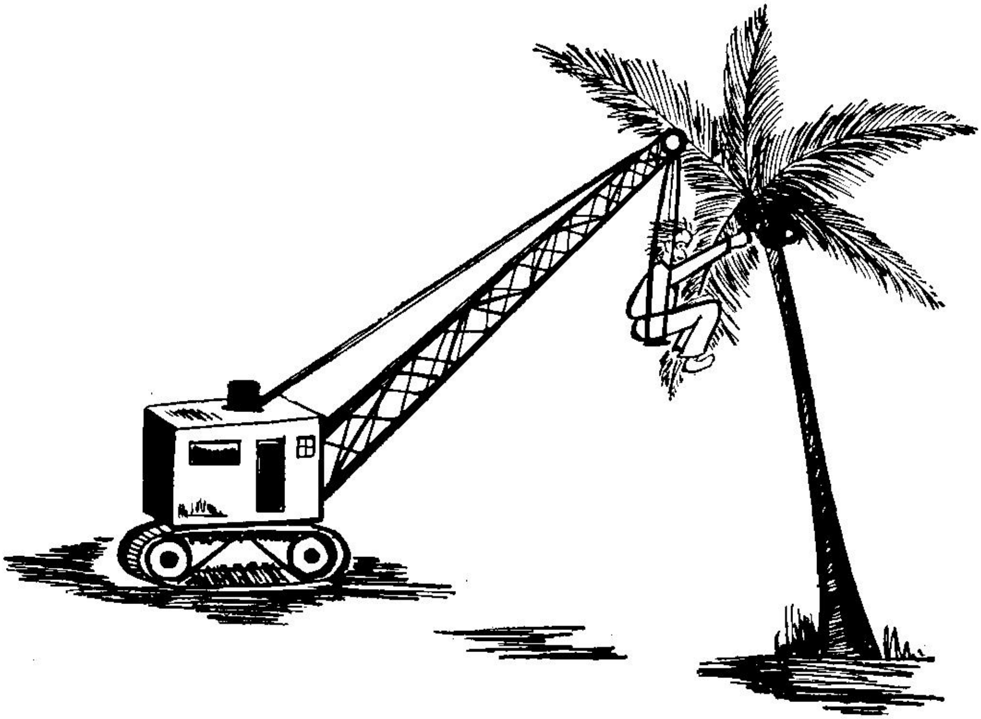
After taking the materials handling picture, try to reduce the handling. Most improvements can be made only if money is spent for rearrangements or for equipment. But look into all the possibilities for making improvements without spending money before you start recommending changes that cost something.

It is not always easy to tell whether you should make a costly change, because the usual accounting records don't give you the figures you need for judging. Except for the scarcity of data, the problem is much like buying new machines to replace old ones. In both cases the important thing to remember is the long-run *cost per unit of product*, not the initial investment. Expensive equipment often produces low handling costs per unit over the years.

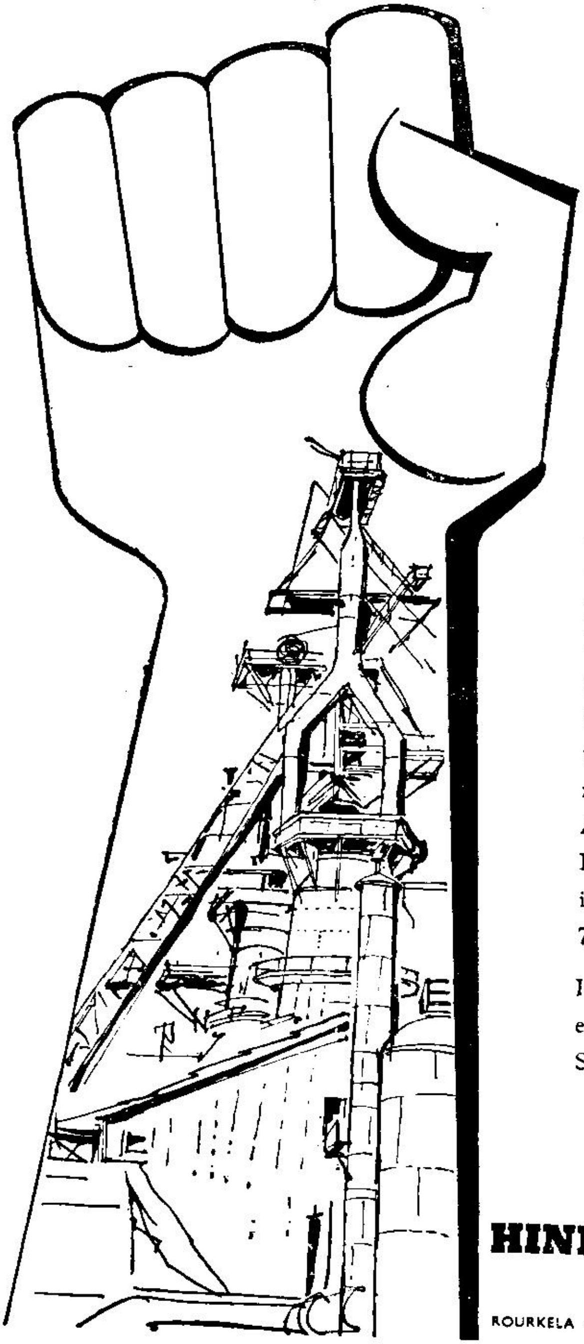
A comparison analysis should include all items of cost and savings. If mechanization will reduce breakage, this saving should be added to the savings in direct labour. If a change to fork-lift trucks requires more aisle space than hand trucking, the cost of providing it should be included in any comparison of costs of the two methods. If the costs of performing preceding or succeeding operations are affected, these items should also be included.

Cost comparisons between the existing and the proposed methods of handling should consider the number of pieces of equipment needed and the number of years they will last. To get the number needed you have to know how fast the handling equipment will travel, how fast it can be loaded and unloaded, and how much time it will be idle. Knowing this lets you figure the amount of materials that one new piece of equipment will move, which in turn tells you how many pieces of equipment you need.

Cost is not the only element to be considered in selecting materials-handling equipment. Other factors must be considered: the space required by the equipment in use, its flexibility, how it is powered, ease of operation, speed of operation, safety, durability.



STRONGER THAN STEEL



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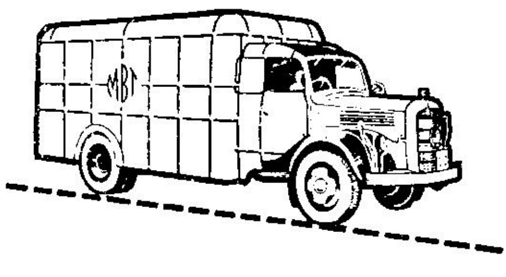

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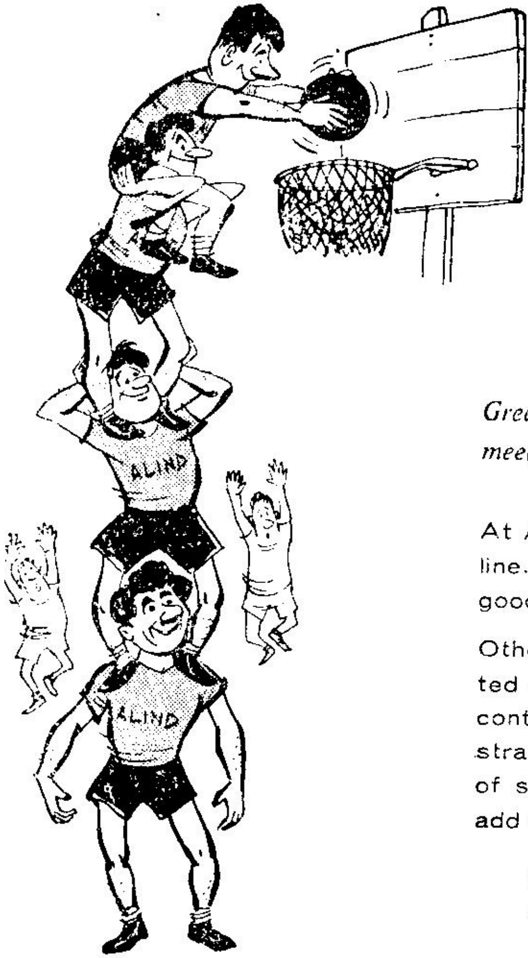

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—WILLIAM BLAKE

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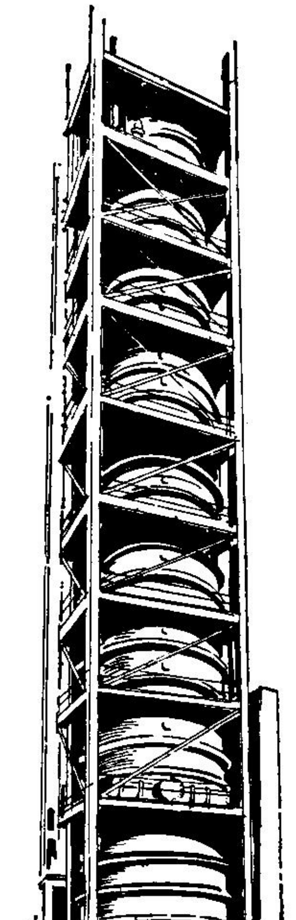

Measuring Materials Handling Efficiency

DULEEP SINGH*

Most of our industrial activity really comprises handling of materials : handling materials from suppliers to stores; from stores to the first operation; then through a series of subsequent operations, inspections and temporary storages located in various departments and shops of the plant to the finished goods stores and finally to the consumer through several godowns, wholesale and retail stores. This perhaps is an over-simplification of the complex nature and extent of the handling of industrial products. At each point in the handling cycle, the material is loaded, unloaded, aligned, positioned, oriented, picked up, moved, released etc., all of which constitute materials handling. If there is any single industrial acitivity which in the aggregate takes the largest part of the consumer's rupee, it is materials handling. It is futile in this context to argue whether or not materials handling adds to the value in proportion to its share of the cost, for no matter how the argument turns, we are all agreed on the maximum economisation of materials handling. It does, however, very obviously add to "time and place utility". Be that as it may, it does constitute the most lucrative area for cost reduction.

REDUCTION IN MATERIALS HANDLING cost has been and is the principal constituent of the rapid growth and development of production technology. *The entire concept of automation and mechanisation is fulcrumed around the need for reducing materials handling.* In fact, automation and mechanisation which are the bases of modern production technology are nothing but attempts towards elimination or simplification of materials handling.

So basic and fundamental is the problem of materials handling, yet there have been very few analytical attempts towards measuring the efficiency of materials handling. Many principles of good materials handling have been evolved and many efficient and ingenious handling devices have been invented and manufactured but no universal measure has yet been worked out to show how efficient is the handling of materials in any plant or in any section of the plant or for any one product as a whole.

percentage of total cost

The one measure that is commonly used is the *handling cost as a percentage of total cost.* Though this is a good means of comparing materials handling efficiency of a given plant with the known efficiencies of other plants manufacturing similar types of products, it does not give the absolute value of the efficiency and consequently does not show how more efficient materials handling could be. This method of measurement also does not enable comparison of inter-industry handling performances. For instance if the handling cost in industry 'A' is 40 percent of the total cost and in industry 'B' it is 20 percent, it does not necessarily mean that industry 'B' is more efficient in its handling than industry 'A'. For all that we know the difference in the percentages may as well be due to the nature of the

*Training Director NPC.

materials to be handled or perhaps due to dissimilar cost structure, that is, varying inter-cost factor relationships.

equipment utilization

Another commonly used index for materials handling performance is equipment and/or personnel utilization percentage. This index is often interpreted as materials handling efficiency. This does not appear to be a wholesome interpretation of either the term utilization or efficiency. Utilization percentage is only the extent to which the available time of the handling equipment and personnel is utilized while working within given technical conditions. On the other hand efficiency is much more comprehensive than utilisation of time. It should measure not only the utilization of time but also the *efficiency of the method and the system*.

An attempt has been made here to present an empirical formula for measuring the efficiency of materials handling which may measure performance of all factors that contribute to materials handling cost. Some preliminary definitions are however necessary for the analysis. Materials handling is the movement of materials, horizontally or vertically from one position and place to another *except when the movement itself constitutes an operation or inspection*. These movements in a plant are of two types, namely primary and secondary movements. The primary movements constitute movements of materials between work, storage or inspection areas. The secondary movements constitute movements of materials at individual workplaces or benches for loading materials on and off the machines, jigs, fixtures, and other devices, for fetching tools etc. This article is mainly devoted to measurement of the efficiency of primary movements.

Strictly speaking materials handling constitutes handling of all kinds of industrial materials; raw, semifinished, finished, including packing materials; indirect materials or supplies; scraps, cuttings, clips and any other kind of waste; tools, jigs, and fixtures etc. Materials handling efficiency can be measured for any one type of material or for all materials. Normally it will be convenient and adequate to measure the handling efficiency of only the major types of materials, accounting for about 75 per-cent of the total weight of materials handled.

materials handling efficiency

The efficiency of materials handling mainly depends upon the following factors : (*i*) efficiency of the handling *methods* employed for handling a unit through a unit distance (*ii*) efficiency of the layout which determines the distance through which materials have to be handled (*iii*) utilization of the handling facilities (*iv*) efficiency of the speed of handling.

By a suitable selection of the unit of measurement, items (*i*) and (*iii*) can be combined to form a single value representing the efficiency of the methods and the facilities. Item (*iv*) although important in certain cases is very difficult to evaluate. In any case its significance in most situations inside the plant will not be large. Hence this factor may be omitted without significantly affecting the utility or accuracy of the value of efficiency.

The handling efficiency is, therefore, the product of the efficiency of the method and facilities and the efficiency of layout. It may also be stated as follows :—

$$\text{materials handling efficiency} = \left\{\begin{array}{l}\text{efficiency of handling methods and}\\\text{facilities}\end{array}\right\} \times \left\{\begin{array}{l}\text{efficiency of}\\\text{layout}\end{array}\right\}$$

efficiency of handling

For determining efficiency it is necessary firstly to have a unit with which to measure and secondly a standard with which to compare the actual. The best unit for evaluating a method is the cost. The efficiency of the method and the facilities can thus be determined by comparing the actual cost of handling with the standard cost. The standard cost in this case is the cost of handling the same materials through the same distance by standard means, that is, by the most ideal method.

It is, however, not possible to determine the most ideal method which can be a standard for all types of materials and at all times. What we can determine or what we know is a method, worse than which is not likely to exist. This method is the *manual handling*. This concept implies that it is very unlikely (although theoretically not impossible) that there will be any situation in industry where a method which is worse or more costly than a *purely manual* method will exist. Purely manual here means a method which involves use of only the body-members and the energy of human beings. This method may be called an *adverse method*.

If we can determine or imagine a ratio between the adverse method and the most ideal or standard method, the knowledge of the cost of adverse method can enable us to determine the cost of the standard method. This ratio will obviously be the *Technological Improvement Factor*. It will represent the improvement which modern technology can bring about in materials handling.

The efficiency of materials handling method and facilities can thus be formulated as follows :—

$$\left.\begin{array}{l}\text{efficiency of}\\ \text{method and}\\ \text{facilities}\end{array}\right\} = \frac{\text{cost of adverse method}}{\left\{\begin{array}{l}\text{technological}\\ \text{improvement}\\ \text{factor}\end{array}\right\}\left\{\begin{array}{l}\text{actual cost}\\ \text{of handling}\end{array}\right\}} \times 100$$

technological improvement factor

Determination of the Technological Improvement Factor may require some research. However, for the purpose of illustration and for all preliminary purposes this factor may be taken as 10, which appears to be a likely value. It may be mentioned here that introduction of this factor in the efficiency measurement is not very critical.

The only effect which this factor has is on the numerical value of the efficiency and not on its relative value. That means that even if this factor is not accurate (it may perhaps be impossible to determine its accurate value) the utility of this value of efficiency as a means of comparing the handling performance of any two plants will not be impaired. What might happen is that we may not be able to deduce accurately how inefficient or efficient the materials handling of a plant is as compared to the standard or the most ideal situation.

cost of adverse method

The cost of the adverse method can be determined on the basis of total "foot-pounds" handled during a certain period of time, the man-hours required to handle this amount manually and the hourly wages prevalent for such manual work. The foot-pounds handled can be determined by the aggregate of the product of the weight and distance handled.

Let $w_1\ w_2\ w_3 \ldots w_n$ be the weights in lb handled,

$d_1\ d_2\ d_3 \ldots d_n$ the distances in feet through which each of the above weights are handled,

w_0 the weight handled manually by one man at one time,

S_0 the standard speed of walking without load in feet per hour,

S_1 the standard speed of walking with load in feet per hour,

and h, the hourly wages in rupees including overheads.

In mathematical terms, the cost of handling would be $= \frac{h}{w_0} \frac{(S_0+S_1)}{S_0\ S_1} \times \Sigma\, wd.$

For the purpose of efficiency calculation w_0, the weight which can be handled at one time by one man can be taken as 60 lb (which is the usual practice). So the walking speed without load, can be taken as 3 miles per hour or 15,890 feet per hour; and S_1, the walking speed with 60 lb load, can be taken as 2.2 miles per hour or 11,616 feet per hour. Accordingly the total cost of handling will be :

$$\frac{h \sum wd}{400{,}000}$$

actual cost of handling

The actual cost of handling should include all fixed and operational costs pertaining to materials-handling equipment and personnel. For the equipment it should include interest on capital, depreciation, maintenance, insurance, taxes (if any), fuel, power, garage facilities, wages, allowances and overheads of operators etc. For manual handling it should include wages, allowances and overheads of handling workers.

efficiency of plant layout

As discussed earlier, the efficiency of materials handling is composed of two factors—the efficiency of method and the efficiency of layout. While the former represents the quality of the handling, the latter denotes the extent of handling. Although a good layout has many objectives to satisfy, and is affected by many considerations, in this context the measurement of layout efficiency will obviously be restricted to only one consideration that is the distances through which materials have to be moved. In view of this the layout efficiency so measured will not necessarily represent the real efficiency, for the real efficiency is the overall advantage which a given layout brings. Quite often in a layout, the distances may have to be increased to obtain other advantages and overall economy in the operation. For the limited purpose of measuring the efficiency of materials handling, however, we have to measure only the effectiveness of the layout in reducing materials handling.

The efficiency of layout, for this purpose, can be measured by comparing the actual distances through which materials are handled with the ideally minimum distances achievable, which may be called the standard distances.

$$\text{Layout efficiency} = \frac{\text{Standard distances}}{\text{Actual distances}} \times 100$$

standard distance

It may rather be difficult (quite often impossible) to state as to what is the minimum achievable distance through which materials should be handled under given operational conditions. This is mainly because there are many considerations which affect the distances, such as the topography of the site, the layout and construction of the buildings, the fire and other hazards, the length of machines and equipment, the handling devices, the departmentalisation, the service facilities, the process, the sequence and number of operations, the storage areas etc. However, it is possible to calculate the theoretically minimum distance by considering only one or two of the above factors as determinants of the layout. Such a minimum distance may or may not be achievable but it will be good enough for evaluating the handling efficiency of the layout. The choice of the factors as determinants of the minimum distance will vary from plant to plant. The main objective should be to choose that factor or consideration which is the single most important under given circumstances. For instance in certain cases the layout of building may be selected as the most important factor in view of its permanent nature. In such a case the minimum distance will be the sum of the lengths or widths (depending on the direction of flow) of the buildings and the minimum inter-building distances in the right sequence. In most cases, however, it will be more realistic to take the existing process (the existing number and sequence of operations) and the lengths of production machines as the determinants of the minimum distances. The minimum distance will be the sum of the lengths of machines and work-places for all operations, inspection and storages. For illustration

let $l_1, l_2, l_3, \ldots l_n$ be the lengths of all machines and workplaces in the sequence of operations. (If two or more operations are performed on one machine, only one machine length will be considered) then, the ideally minimum distance or the standard distance $= l_1 + l_2 + l_3 + \ldots\ldots l_n$

$= \Sigma l$

actual distance

The actual distance is the sum of the distances through which materials are moved according to present layout and other operational considerations. These distances are the same as those determined for calculating the total foot-pounds handled.

the total actual distance $= d_1 + d_2 + d_3 + \ldots\ldots d_n$
$= \Sigma d$

The layout efficiency can thus be formulated as follows : $\frac{\Sigma l}{\Sigma d} \times 100$

the final formula

The final formula for the efficiency of materials handling can now be consolidated as follows :

$$\text{efficiency of materials handling} = \left\{ \begin{array}{c}\text{efficiency of handling} \\ \text{methods and facilities}\end{array} \right\} \times \left\{ \begin{array}{c}\text{efficiency} \\ \text{of} \\ \text{layout}\end{array} \right\} \times 100$$

$$= \frac{(\text{cost of adverse method})}{\left\{ \begin{array}{c}\text{technological} \\ \text{improvement} \\ \text{factor}\end{array} \right\} \left\{ \begin{array}{c}\text{actual} \\ \text{cost of} \\ \text{handling}\end{array} \right\}} \times \frac{(\text{standard distances})}{(\text{actual distances})} \times 100$$

$$= \frac{\left(\frac{h\,\Sigma wd}{400{,}000} \right)}{10 \times C} \times \frac{\Sigma l}{\Sigma d} \times 100$$

where h = hourly wages
w = weight handled
d = actual distance handled
l = standard distance
C = actual cost of handling

To illustrate the formula let us consider a plant which has an actual materials handling cost of Rs. 6,000 per month, handles 100 tons of materials per month through a distance of about 1,60,000 feet and has an hourly wage (including overheads) of Rs. 0.50 for workers imployed on handling. The total length of all production machines and work areas used for operations, inspections and storages is 50,000 feet.

Thus $h = 0.50$; $\Sigma wd = 100 \times 2240 \times 160{,}000$

$\Sigma d = 160{,}000$; $\Sigma l = 50{,}000$; $C = 6{,}000$

Efficiency of materials handling $= 23.4\%$

The formulation of materials handling efficiency presented in this article is an initial attempt towards measurement. As such, it should provide a scope for refinement to those interested in the subject. In its present form, however, it may be a useful tool for the management for a realistic evaluation of the materials handling performance within its area of responsibility. It brings to the management a knowledge of the margin by which the cost to the consumer can be possibly reduced at the present level of technological development.

Measurement of Fork Truck Performance

ROBERT LEE MORROW*

A joint research project by the Materials Handling Division of the Yale and Towne Manufacturing Company and the Wharton School, University of Pennsylvania, resulted in the formulating of operation procedures and tables for basic motion times for operation of electric fork trucks, a type of truck quite generally used.

FORK TRUCKS WERE STUDIED IN 18 plants. Studies were confined to 4,000 to 6,000 pound electric fork trucks, which are popular sizes. Memo-motion movies (100 frames per minute) provided the standard times for basic trucks motions. To measure times for basic truck motions, time requirements for different loads, the truck under observation handled a 4-cubic foot load (including pallet) of a thousand to 4 thousand pounds. The operator selected for each test was a 'normal' qualified operator who was required to operate the truck at maximum capacity, observing safe practices. He performed all hoist and tilt movements while the truck was at rest. Only two basic motions showed much variation, namely 'run-in' and 'run-out'. Actual times were levelled in order to obtain the standards.

To the times thus obtained, allowances will have to be added to cover unavoidable delays and variations caused by the human element, mechanical conditions, and conditions of operation.

As is usual in studying operations, the determination of delays and interruptions not only shows the allowances that have to be made (when these delays and interruptions are unavoidable) but it *puts the spotlight on the places where improvements should be made to avoid avoidable delays.* In figuring how many trucks are needed, it is essential to check each operator's performance under local conditions. This can be done from studies on the operators with the basic times. If, for example, each operator showed 80 percent of normal performance and you had figured 4 trucks, actual need will be 4 divided by 80 percent = 5 trucks. Possibly one or more of your operators needs more training; perhaps some of them are physically unfit for the job or lack the necessary aptitude. An incentive plan may be indicated to bring their work effort up to normal.

Idle time beyond control of the operator may be due to ineffective supervision or it may be because of conditions beyond the company's control. For example, in one shipping department it was found that few outside carriers sent their trucks for loading in the morning; the heaviest shipments were in the late afternoon. Further investigation showed that the carriers wanted to load company A's merchandise on top of

*Columbia University.

goods already in the trucks, because company A's merchandise was light-weight. Some improvement was obtained by a better scheduling of truck-arrivals by carriers and by arranging to give company A's loading crew more men at times of peak load. Conditions of this kind, if not corrected, require additional time allowances and consequent unnecessary additional cost to the manufacturer.

The condition of your trucks is a factor to be considered. If the trucks seem not in good mechanical condition and are frequently delayed in their trips in order to make minor adjustments, these delays should be taken account of and allowed for in the time standards. The time lost through such delays can be determined from work sampling studies. When the studies for basic times were made, the truck batteries were fully charged. For battery usage over 5 hours, allowances should be made.

When trucks are operated for short distances they cannot usually be driven at full speed and the basic times should be increased to cover this condition. In the operation of trucks certain delays may occur, caused by pedestrians or other vehicles in the way, by containers, skids or pallets, or other material standing in the aisles, by poor scheduling, or by passage of trucks through doorways. Delay allowances for these conditions can be obtained from work sampling or interruption studies. Work sampling is the least expensive to apply and most rapid to complete.

Where obstructions, such as low headroom or narrow passages (other than doorways), require a truck to come to a stop and restart, the tables should give times for 'stop' and 'acceleration' from which the lost time can be estimated.

Temperature should be taken into account when figuring time standards. Between 32° and 90° no allowance is needed; above or below this range, add 10 percent. Weather conditions, rain or snow, may necessitate an aditional 10 percent allowance when trucks are operated outdoors.

Significance of Materials Handling

KB Warwick*

To produce a motor car by hand would cost some 18 times the price of the mass produced family model. Here, mechanical handling of the raw materials, machined and pressed parts, metal finishing and assembly on integrated systems of over-head, floor and slat conveyors can surely claim the greatest share of the vast economies effected by saving in manpower, reduction in inventory of work-in-progress and great improvements in cleanliness and safety in the factories. The field of bulk handling has also resulted in tremendous advantages, not only in savings in the cost of the finished article but in many cases in *the very fact that the process just could not be achieved in any other way*. One can, for example, take the disposal of flyash from a coal burning power station. Around 2,000 tons of this material must be removed every day, and mechanical handling is the only economic method of achieving this.

When mechanical handling is installed, safety is installed. Most factory accidents are caused by falls and crushings, bad stackings, cluttered gangways, and workers rushing about and carrying bulky loads. All these risks can be removed by mechanical handling in its various forms and the man in the factory is assured of a great reduction in accident risk. This is also true of the articles conveyed: delicate instruments or green foundry cores are carried safe and secure and television sets are even tested as they speed along on overhead conveyor tracks.

Molten metals are conveyed, chain conveyors go through ovens with temperatures much in excess of those applicable only a few years back. Conveyor systems are integrated not only with individual processes but with the entire tempo of a complete factory. Live storage is assured and the highly complex electronic controls ensure that the article is there just at the moment it is required.

In pre-war days, one often heard of the Slaves of the Belt and now and again the fear of unemployment caused by automation arises. However, the modern trade union leader is well aware of the advantages of mechanical handling. At a recent meeting, a prominent union leader reproved one of his members with the remark : *Go back to the stage coach and see if that improves your living standards*.

*General Manager, George W King, UK.

cost considerations

The cost aspect of mechanical handling is paramount for a nation whose prosperity depends upon export. Reduction in costs can be assured in several ways—less man-hours per operation, less work in progress, less stocks in hand, quicker turnover, less damage to work in transit, less time losses due to accidents to personnel, less time lost due to delays in transit to assembly areas. All these progressively can have a marked effect in reducing handling charges, which have been estimated to account for 85 percent of the total of indirect labour costs. In some trades, one is told that 17s 6d of every £ 1 is accounted for in transporting and handling. Here, surely, is the place to attack in the battle of price reduction. Rents, rates, wages, salaries, power, raw material costs—these are fixed externally, In the first instance, however, the economics of the various means of handling should be carefully worked out. The following may well serve as an illustration.

We have to move say 1000×8 cartons of palletized load across 40 ft and stack them. In terms of time the cost would be as follows :

		men-seconds
1.	manual handling ..	288×10^4
2.	using a platform truck ..	240×10^4
3.	using a conveyor ..	144×10^4
4.	using a fork-lift truck ..	4×10^4

It is, however, not only the statistical part of the materials handling that is important. In fact the statistics have also to be based on facts. Hence for evolving an economical and workable programme of materials handling, the following steps should be taken :

Get the information, study the problem carefully. Break it down in simple yet understandable parts, e.g. what is to be moved, where to be moved, quantities to be moved, and the time required for the operations. Know each part. Determine how well this can be done. Proceed to try available methods of recording the necessary information for a more scientific analysis. Prepare a flow diagram of the situation and draw a flow chart as shown below:

analyse the information analyse the collected data for a closer check. Design the means to eliminate unrequired motions. Minimise the length of the moves. Select equipment to reduce the more tiring operation to an easy and labour-saving one.

develop and instal the programme assemble the analysed facts. Decide the means of handling, e.g. hand-trucks, conveyors, lift-trucks, etc., to suit the needs of the plan. Prepare details. Know how to instal. Be patient to wait for results.

evaluate results determine from the records what the unit cost is under the present handling system and what the cost would be after installation of the new plant. It is advisable to compare results with other concerns of similar kind, the principle being to keep down manpower requirements of handling time.

WORK AT BEING A LION

A young lion, shipped to a small zoo, e t quite superior to an old lion in the next cage who did nothing but loaf and lie about. "That's no way for a lion to behave !" he thought, so he aced up and down, roared at visitors and clawed the bars of his cage. When the keeper threw a big chunk of steak to the old lion, but gave the new arrival only two bananas and a bag of peanuts, the young lion complained, "I don't get it. I work at being a lion, and look what happens. You lie there like a rug and get a full meal.". . ."Young fel w," the old lion said tolerantly, "this is a small town and a small zoo. T e budget can't stand two lions. You're booked in here as a monkey."

Planning A Handling Programme

SM Misra*

Planning a handling programme under technical conditions has necessarily got to be a tailored programme. The transportation for example of liquid oxygen at -297°F would in any case be a highly specialised job. That it is effectively done shows the tremendous progress made in recent times in the direction of materials handling. In Canada molten iron is transported by rail to a distant place. The exploitation of atomic energy would not have been possible but for the development of handling methods in respect of ratiation materials. These, of course, are extraordinary achievements but handling is a common operation almost everywhere in restaurants, laundry-shops, banks, hospitals, dairies, farms, post-offices, factories, practically at every place. In a technological society, therefore, there is bound to be application of technology to the transport of materials including papers. In the United States for example, in multistoreyed buildings which are common, a pneumatically operated Lamson-tube system carries messages to the various sections of an office located at different floors. Mechanical handling of mail in post-offices has greatly improved the efficiency of the system. As said before, materials handling has necessarily to be tailored to the pecularities of an organisation. In a modern chemical plant for example, handling is built in the processing equipment itself. In a mass producing firm on the other hand, which makes an engineering product, the flow of materials is to be devised in view of the requirements, costs, returns, and several other factors. Very obviously the field of materials handling goes alongside what is now known as operations research for it is a field which requires an inter-disciplinary approach including work study, plant layout, the mechanics of manual versus mechanical handling and so on.

In most factories particularly in the United States pallets have been resorted to for elementary movements of materials. A firm has to decide upon a certain unit load system and obtain proper pallets or skids for in-factory transportation. A unit load in this connection may be self-contained as for example roll of spun yarn, cables, paper rolls, etc. There are other loads which require the use of pallet, skid or other device such as carton, bag, etc. Loads are also handled without pallets, skids or other supporting structures. But pallets and skids are the basic device which are now being widely used. The principal difference between the skid and the pallet is in the height of the load supporting platform. Skid is designed to be handled by a platform truck and its under-clearance must thus be sufficient to permit entry of platform. Stack-racks of tilt and horizontal types serve a good example for skids. They can be stacked to any height, one over the other with the use of a lift truck. Pallets are designed to be handled by a fork type truck and have a lower under-clearance.

* Asstt. Engineer, Satna Cement Works, Satna

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Productivity and Handling

SRIPATI RANGANADHA*

Materials inventory and materials handling are two of the important constituents of control of materials. They form one of the major aspects of materials management activities. The former helps to assure a balance between the desired kind and required amounts of materials within an enterprise in order to make it yield the maximum turn over; whereas the latter emphasises the utility of special tools and techniques to help in the reduction of direct labour costs, accidents, product damage and improved flow of materials through the plant and thus accomplishes maximum returns with minimum time, money and effort.

THE COST OF HANDLING OF MATERIALS within an enterprise varies from plant to plant and depends upon the nature of the product and the degree of automation. The cost, for instance, per unit of materials handling in light metal working manufacture, will be definitely less than one in an iron and steel factory. The layout of the plant also affects the cost structure. Moving materials and plant layout are closely akin to each other. A low handling cost per unit implies that the plant layout is efficient and it is possible to turn out products at a minimum cost. Materials-handling methods tend to affect production costs. Very often workers unnecessarily move materials in an enterprise and as such imperceptibly enhance the overall costs. A series of picking up and laying down tools and materials eventually add to cost but not to value.

Of late, certain basic ratios (such as materials handling labour costs to total pay role) have assumed vital importance in modern enterprises. The aim of the ratios is to analyse the materials-handling costs and thereby attempt to reduce them. These procedures have given rise to *typical* savings in certain manufacturing concerns in the USA. Materials Handling Labour Ratio referred to labour is one of the indices to indicate the efficiency of modern enterprise. The ratio differs from industry to industry and varies also with respect to the nature of product and the degree of automation. It is generally believed that a ratio of 20 percent indicates scope for improvement and a ratio of 9 percent is usually taken to be a hint for pretty good business. Another ratio called the Direct Labour Handling Loss (DLHL) Ratio is also being worked out in certain concerns. Much labour is being lost in many concerns because skilled men are harnessed to unskilled handling. Direct Labour Handling Loss is a measure of this lopsided distribution. This ratio can be worked out by a study to see as to how much a particular piece of work comprises materials handling and other labour. This study can be directed either in an informal spot check or itemising all the materials handling work executed by each productive worker. The percentage of direct labour (other than work feeding) in terms of handling is evaluated. Thus

$$DLHL = \frac{\text{MH time lost by direct labour}}{\text{Total direct labour time}}$$

* Senior Research Officer, Indian Institute for Population Studies, Madras.

The arrived percentage is multiplied by total wages to obtain the money value of time lost. It is stated that a DLHL exceeding 15 percent is a sign of warning that skilled labour is being wasted on excessive handling.

Another significant ratio (Movement/Operation Ratio) is designed to curtail unnecessary movements in handling, so that relative efficiency could be enhanced for a given productive operation. This ratio of operation is calculated by the actual total moves of workers and machines and divided by the number of operations (in assembly and inspection). The numerator can be figured out by counting the moves while walking through the factory. Thus

$$\text{Movement/Operation Ratio} = \frac{\text{Number of Moves}}{\text{Operations}}$$

It is estimated according to experts that a ratio of 4 to 1 is a good enough target for a shop job while 3 to 1 ratio for conveyorized systems.

Another line of analysis goes by the name of Manufacturing Cycle Efficiency. It goes to show how effectively and rapidly a factory feeds materials in a required process and to see whether they experience any clogging and cluttering hampering the regular flow of materials through the plant. It also brings to light the reasons for the slow manufacturing process.

The Manufacturing Cycle Efficiency can be computed by dividing the total time required for productive work into the elapsed time from start to finish of an order. Thus

$$\text{Manufacturing Cycle Efficiency} = \frac{\text{Total Time for Production Operations}}{\text{Elapsed Time.}}$$

The production operation involves machining, moulding, heat treatment, inspection, packaging and the like. The time taken on each operation is itemized and totalled in unit of hours. Similarly elapsed time is taken to mean the total time spent to turn out a certain job in a factory.

To illustrate in numerical figures

production operations

shaping and machining	6 hrs 20 mins.
moulding	1 hr 30 mins.
hammering	50 mins.
polishing	20 mins.
Total	9 hrs.

elapsed time

11 days and 2 hours that is 90 working hours

$$\therefore \text{Manufacturing Cycle Efficiency} = \frac{\text{Production Operations}}{\text{Elapsed Time}} = 9/90 = 10\%$$

Experience shows that very few shop operations have even a 10 percent Manufacturing Cycle Efficiency. It simply means that a product needs less than an hour for production operation, but the plant takes to finish it in 10 hours. The efficiency of such marginal firms may stem from many obvious failings. Communications, handling and better production control can provide an effective response for such a failure.

equipment utilization

A low equipment utilization ratio may be the result of inadequate handling tools and machines, inefficient maintenance, slow and sloppy supply of material, improper feeding, worn out parts, breakdown and similar other shortcomings. The aim of this ratio is to determine whether the production equipment is being utilized to its full capacity. A comparison of an actual capacity of production equipment with its theoretical potential gives rise to Equipment Utilization. Thus

$$\text{Equipment Utilization} = \frac{\text{Actual Output}}{\text{Theoretical Capacity}}$$

Equipment utilization not only varies from firm to firm but from industry to industry as well. The efficiency for automobile industry in the US for instance, before automation was around 60 percent and since then it has shot up to 80 percent. This obviously is due to improved materials handling. It is also to be noted that the efficiency of certain textile plants has gone up to 95 percent. There is really no ceiling figure to indicate the top efficiency of a firm. A still more significant ratio from the point of view of materials handling is the one relating to Space Utilization Efficiency. It is a comparison of the space available and the space usefully occupied. The actual space is the interior cubical volume of the building. Full utilization does not mean any disregard for the convenience or health of the persons who have to work inside, but making all such allowances and the paramount necessity of the even flow of materials, a watch has to be kept on the ratio of cubical to utilized space as a significant criterion for finding efficiency. In this connection, attention has got to be paid to aisle space, whether existing aisle space can be narrowed in order to save either for storage or production. It would be also practicable if new narrow aisle trucks are made to order for sharp turns to save space. In fact, extravagance in aisle space runs the risk of storing all kinds of items without any scientific procedure. Gross indifference to this may be attributed to poor organisation of a plant or a warehouse. This may also stem from the ignorance of modern kind of materials-handling equipment.

To conclude, the above few ratios are self evident to indicate their importance in the light of the overall productivity of a concern. The aggregate effective implications of these ratios are bound to *shrink time effort and money to a minimum in the long run, which is the essence of Productivity.*

Cost Accounting for Materials Handling

ACCOUNTS NEED NOT BE HATEFUL—JUST because they seem to be nosey, officious fellows. You have more in common with them than you may realize. You're both trying to do the same thing: control costs for more profits. The executive secretary (McClelland) of the American Materials Handling Society suggests a change in attitude towards accounting for materials handling. He asks: "Is there not a revolution underway which tends toward consolidation of all movement and storage of goods in one function and in one account? Could we summarize costs of planning, controlling, and executing the flow of material, then provide the directors of our company with a statement of these costs?" If it's logical to divide warehousing from manufacturing, then it's just as logical to break down manufacturing into (1) production—giving the product saleable shape, creating form value, (2) materials handling—moving and storing goods, creating time and place value. For accounting purposes, McClelland wants to pull out all handling, label it 'materials handling management,' and keep it separate. Then management could be kept informed of material flow costs and be brought to realize that the cost of forming is distorted by mixing flow costs with production costs.

Accountants in most plants have the means to itemize and summarize flow costs. At present, however, accountants do not segregate flow costs and methods would have to be changed. Material flow costs are seldom separated into functional accounts. They're usually allocated to general overhead expense accounts. Instead, I suggest that a company segregate (1) the overall cost for moving and storage (2) costs incurred for specific operations that make the product more saleable. Then the board of this company would have a more useful basis for intelligent decisions.

Use of a Fork-lift Truck

EXAMPLE = the servicing of a Press Shop with material from a Raw Material Stores and removal of finished pressings to an Intermediate Stores.

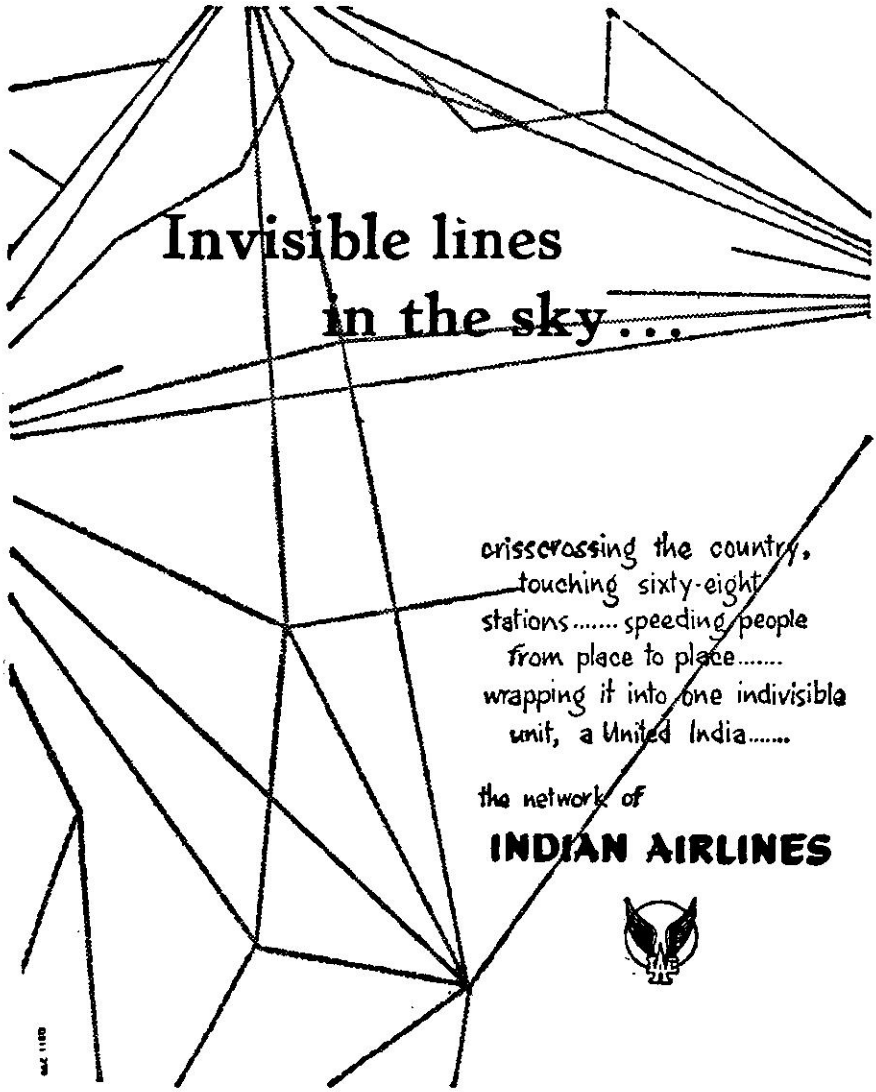
Operation		*Total time (man/mins.)*		
Number	Description	Present method	Existing method	With fork-lift truck
1.	From Yard to Truck Slings & Overhead Crane	3 men × 5 mins.	15 mins.	1 min.
2.	Move to S/M Store	2 men × 5 mins.	10 mins.	4 mins.
3.	Unload Sheets in Store	2 men × 50 mins.	100 mins.	(Combined op. seq 2)
4.	Load Truck and Service Guillotine	2 men × 50 mins.	100 mins.	4 mins.
5.	Fill stillage with cut material ex-Guillotine	1 man × 15 mins.	15 mins.	
6	Transport cut material to Press Shop	2 men × 15 mins.	30 mins.	5 mins.
7.	Off cuts from Guillotine to Scrap Bay	1 man × 20 mins.	20 mins.	5 mins.
8.	Remove finished components from Press to Finishing Department	1 man × 15 mins.	15 mins.	5 mins.
			305 mins.	24 mins.

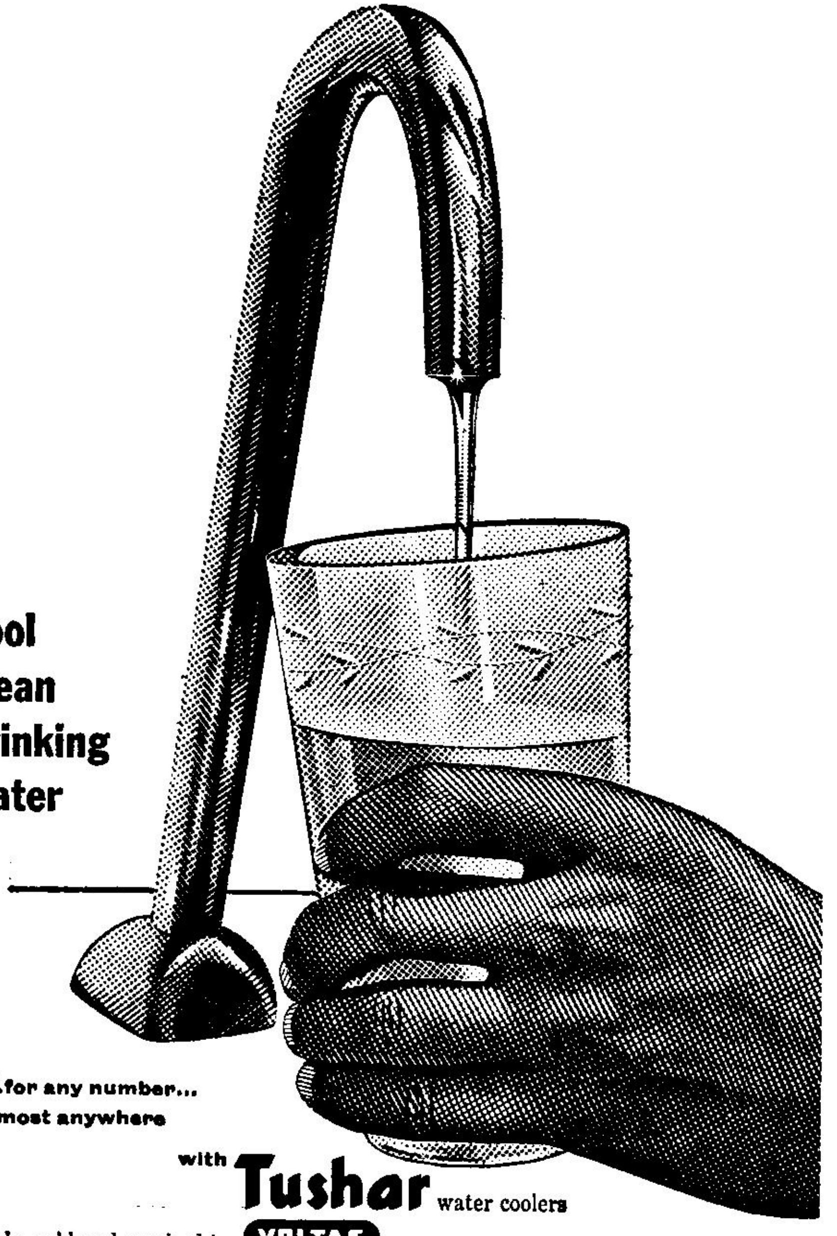
Thus saving = 281 mins. per 2 ton load
Average weekly tonnage—Raw Material Stores to Press Shop = 50 tons

Therefore, saving per week = $\frac{50 \times 281}{2 \times 60}$ = 117 hrs.

Equivalent to $2\frac{1}{2}$ men @ £8.0.0 per week
Saving = £1,000 per annum

From this sum must be deducted the annual cost for the installation and maintenance of the Fork-lift Truck—which at, say, £200 per annum would still leave a saving of £800 per annum.


Invisible lines
in the sky...
crisscrossing the country,
touching sixty-eight
stations....... speeding people
from place to place.......
wrapping it into one indivisible
unit, a United India.......
the network of
INDIAN AIRLINES



NPC Question and Answer Service*

THE EDITOR OF THE PRODUCTIVITY Journal is considering the adoption of a new column which might be termed "Questions and Answers on Industrial Productivity". In this feature, questions will be received from readers concerning productivity problems of a technical nature, and will be answered by Specialists on the staff of the National Productivity Council. Questions and answers will then be published in the Journal and further comments will be welcomed. We hope thereby to make available helpful information to those having difficulties in the maintenance or development of effective management procedures in their offices or factories.

Much management literature is currently available to the public in the library of the NPC and in Local Productivity Councils throughout India. However, the industrial manager is frequently faced with problems which yield more readily to solution when persons having experience and knowledge of industrial production problems are employed in recommending appropriate actions. Not all questions which arise in practical everyday industrial situations can be solved by reference to textbooks or handbooks. The NPC has on its staff both Indian and American personnel whose experience and knowledge are available to our readers for the asking. We will now make available this expert knowledge through this Question and Answer Service. This new endeavour should serve to broaden the understanding of management and supervisory personnel, and will provoke further questions on problems they face.

The questions posed to the Editor will be concerned with any of three categories:

1. Industrial Management
2. Industrial Engineering
3. Industrial Relations.

Questions asked will be limited to approximately 25 words and will preferably pose a problem which is also faced by other industrialists and managers. Questions may be edited for adaptation to the requirement of this Journal.

In order to illustrate the types of questions frequently asked in industry and which are typical of those which may be dealt with by this Service, the following five questions and answers are presented. There are examples of queries frequently directed to Technicians and Engineers of the National Productivity Council :

Q. 1 My mill already has a very high production level and all of my machines are operating at near-full capacity. My workers work very hard. What scope is there for me to increase my productivity ?

A. The writer of this question implies that because both machines and men are employed to a high level there may be little scope for increase in productivity. This is not correct. Productivity is not identical with production. Other areas of increased productivity are available to industry than merely requiring the worker

*For this suggestion, the Editor is obliged to his friend and colleague, Prof. RF Bruckart. In fact, the draft is entirely his.

or the machine to work faster or harder. Reduction in waste, improvement in quality, better materials handling, reduction of inventory levels, and many other areas exist for productivity increases. These should be investigated if the scope of increased productivity is to be fully realised.

Q. 2 In the textile mill in which I am a weaving master, we wish to improve the efficiency of our loom operation. The machine-speed is fixed mechanically, so how is it possible to improve our efficiency level ?

A. It is true that for operating conditions where machine-speeds and feeds are pre-established, the attainment of high productivity is not so simple as when only manual effort is involved. Recent courses given in "Work Study for the Textile Industry" have been presented in various textile centres of India. In the analysis made of loom operations it has been observed that optimum conditions are rarely achieved by requiring maximum output from either men or machines. Reduction in the frequency of ware-breaks and other causes of machine stoppage will serve to improve the efficiency more than an effort to increase output through maximum speed of either weaver or loom.

The application of Work Sampling analysis for determining reasons for and frequency of delays has proven very suitable in improving efficiency of loomshed operations.

Q. 3 What is a good incentive wage scheme for the assembly department of a bicycle manufacturing company ?

A. Incentive Wage Schemes are of many varieties and without further details as to the nature of the operations involved in the assembly department, it is difficult to specify exactly the most suitable Incentive Wage Scheme. The Wage Incentive Schemes presented in NPC courses in Advanced Time Study and Standard Data, suggests that for manual operations a Wage Incentive Scheme paying bonus earnings above the level of standard production on the basis of 1% increase in pay for each 1% increase in production is recommended. It should be understood, however, that any Wage Incentive Scheme assumes that production standards have been established scientifically by time study procedures, which in turn have been preceded by a careful and extensive methods study programme.

Only if effective methods are first developed and proper production standards established by work measurement, a wage incentive scheme will be successful.

Q. 4 How can office efficiency be improved ?

A. The problem of achieving efficiency in offices comparable to that available in production shops is not easily solved. If office procedures are routine in nature, the application of Method Study for achieving the simplest and easiest method, plus a time study programme for determining the expected output levels, can be very effective. In other cases, however, where mental operations are part of the office routine, these procedures are less applicable than for repetitive operations. The most useful introduction to achieving office efficiency, however, is an analysis of the flow of paper-work, the proper design of forms in improving efficiency, the simplification of procedures, eliminating duplication and waste effort, and other similar analytical techniques. In general, application of work study techniques to office operations is quite effective, and the provision of a trained work study man in an office of substantial size should prove a lucrative source of employee efficiency, reduced costs, and more effective despatch of office transactions.

Q. 5. I have read about "Suggestion Boxes," and have heard that they improve worker morale. Is this true ? How do they work ?

A. Suggestion Boxes, if properly introduced, may improve worker morale. The purpose of Suggestion Boxes is to give the workers an opportunity for suggesting to management, ideas and procedures to improve existing operations. Financial rewards are given to those who make suggestions which are acceptable, and this opportunity may have a desirable effect on the morale of workers. Normally Suggestion Boxes are employed only after a method improvement programme has been introduced into the shop.

Materials Handling

MM LUTHAR*

MATERIALS HANDLING IS A FASCINATING SUBJECT and any thorough study of the subject in any workshop generally reveals that very simple and inexpensive gadgets intelligently designed result in saving a lot of manual labour. Some of these gadgets are briefly described below.

Vaccum Cup: The gadget consists of a tubular frame with its suction cups which are connected to a vaccum exhaust through a flexible pipe. The suction cups rest on the plate to be lifted. The exhauster creates the utmost pressure in the lower side of the plate and enables the frame to lift the plates. The number of suction cups can, of course, be varied to suit the weight of the plate. Sketch No. 1 shows this arrangement.

Stillage: There is a lot of swarf and cut metal to be removed from certain machines with a high rate of metal removal. Some of these machines like wheel turning lathes are provided with pits which collect the swarf. In order to ensure its speedy disposal, specially built stillages are kept on the pits which collect the swarf and when they are full they are removed by the help of an overhead crane. The bottom which is normally held in place by carefully designed pins and hinges is capable of opening out by the operation of a lever. The overhead crane takes the stillages on top of an open wagon. The lever is operated and the bottom flaps opened out discharging the swarf and metal cuttings into the wagon. Sketch No. 2 shows this stillage.

Ball Transfers: Ball Transfers with cast steel bodies are generally difficult to get and it has been possible to evolve a simple design of frame for the body of the ball transfer, particularly when flat pieces like heavy plates have to be moved either vertically or horizontally, the use of ball transfers proves very helpful involving very little manual labour to move heavy plates. Sketch No. 3 shows a fabricated ball transfer.

Hand Trolley: Oxy-Acetylene welding generally involves transport of 2 cylinders 10¼″ and 9″ in dia. An ordinary trolley suitably modified to carry the cylinders provided with chains to hold the cylinders in place with double tyred wheels considerably helps in the transport of these cylinders. The trolley is shown on Sketch No. 4.

Long Distance Transport: Where there is no similar traffic it becomes necessary to use collapsible containers so that they can be opened out for transport of goods and collapse for the return journey to save the space. The portable collapsible container made out of alluminium strips cut out of scrap is shown in the sketch No. 5. Wherever necessary argon gas welding is carried out to weld alluminium pieces together.

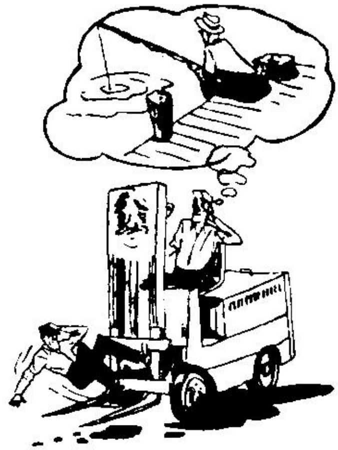
*Works Manager, Central Rly Workshops. Matunga.

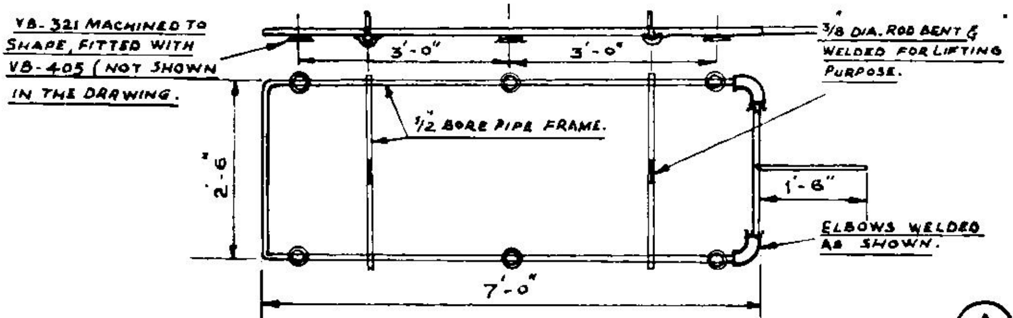
Light Hand Truck: Inter-section and shop transport has frequently to be carried out with the help of hand truck and the hand truck without the use of power is not fully justified. Sketch No. 6 shows a simple design made for a hand truck with the capacity of $2\frac{1}{2}$ cwt.

Revolving Trestle: Sometimes it becomes necessary to support items like wagon underframes which have to be loaded on the wheels. For this purpose, it becomes necessary to support underframes on trestles which can be revolved on a base to enable the underframes being loaded. Sketch No. 7 shows the revolving trestles designed for this purpose.

Pallet Fork-lift Trucks: Fork-lift trucks are coming more and more into use and their utilisation can be seriously hampered unless the suitable pallets for transport and shortage of material are provided. Sketch No. 8 shows a pallet made out of wood for the purpose of Fork-lift Trucks.

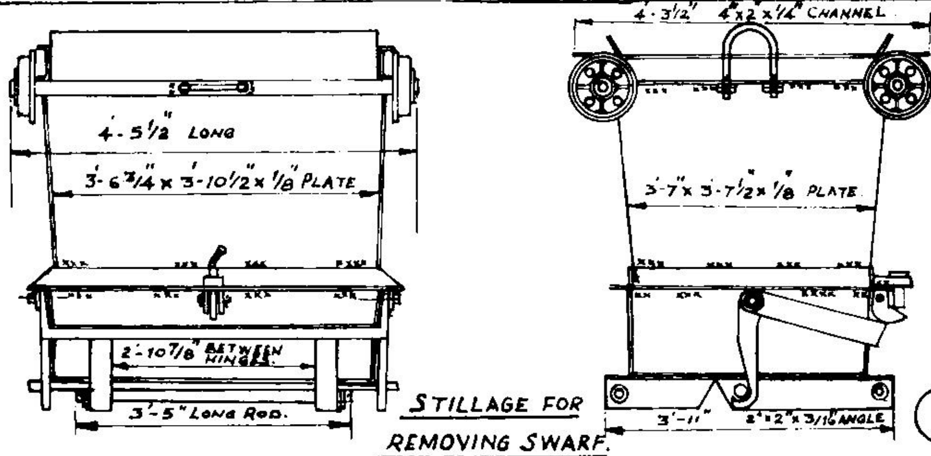
The Grab: In order to save handling time, it becomes sometimes necessary to carry large number of plates and sheets with the help of overhead crane. Sketch No. 9 shows the broad details of the grabs specifically constructed for this purpose. The grab consists of 2 arms which can be fulcrumed and also provides a stop for the movable arms so that they do not swing out more than necessary and cause damage. In the lower end of the arms ordinary pieces of $5'' \times 5'' \times \frac{1}{2}''$ angles are welded to support the plates.





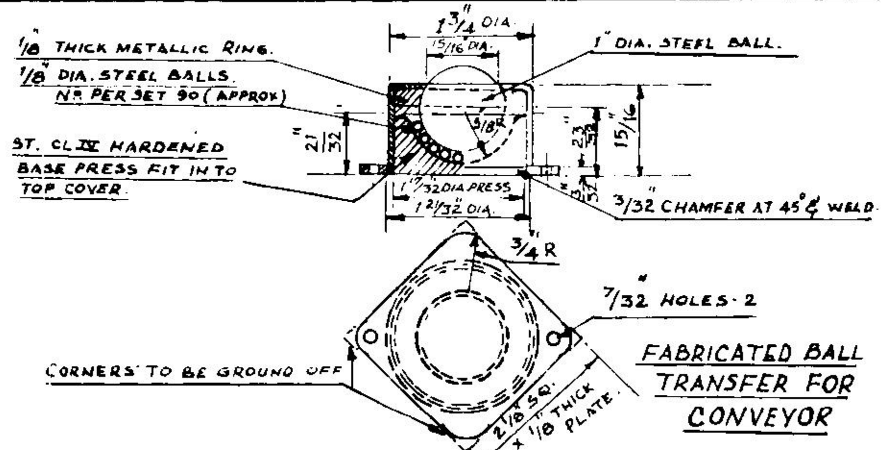
VACUUM CUP ARRANGEMENT FOR HANDLING SHEETS
(ON PRESS BRAKE)

1



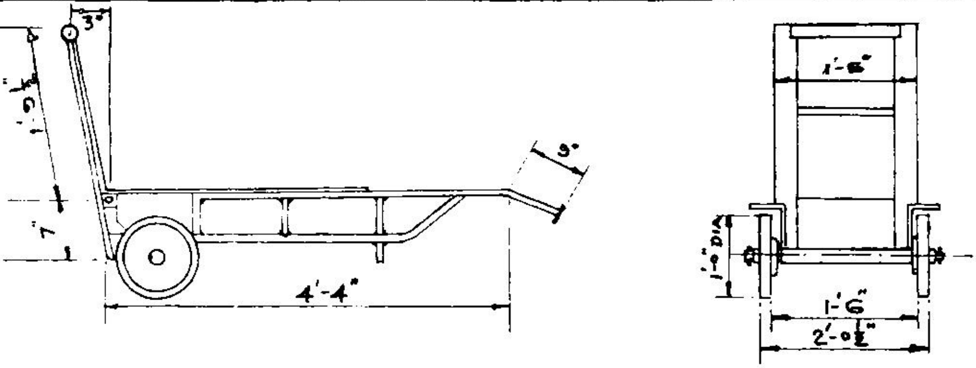
STILLAGE FOR REMOVING SWARF.

2



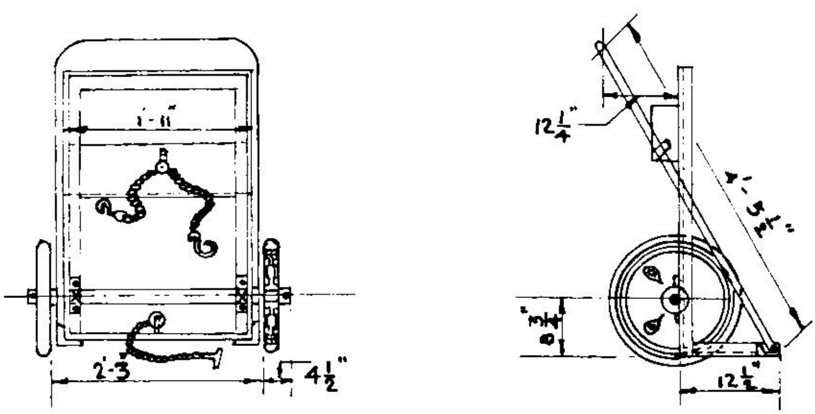
FABRICATED BALL TRANSFER FOR CONVEYOR

3



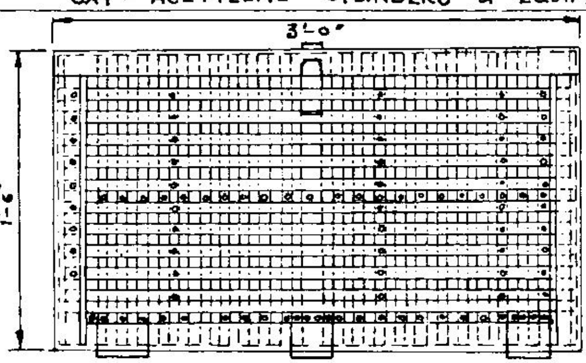
LIGHT HAND TRUCK CAPACITY 2½ CWTS.

⑥



GENERAL ARRANGMENT OF HAND TROLLY FOR CARRYING OXY – ACETYLENE CYLINDERS & EQUIPMENT.

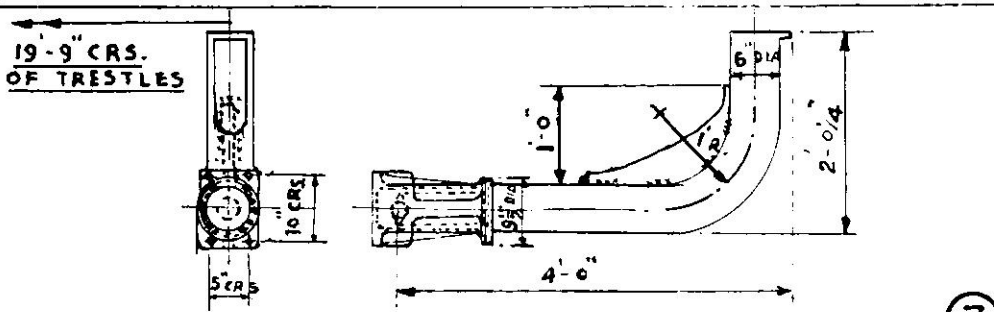
④



PORTABLE COLLAPSIBLE CONTAINER.

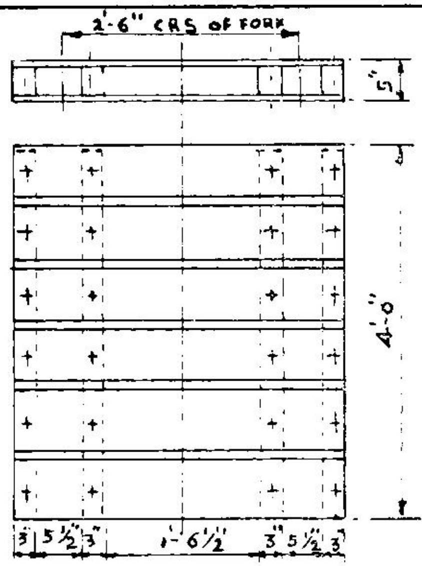
MATERIAL :- ALLUMINIUM.

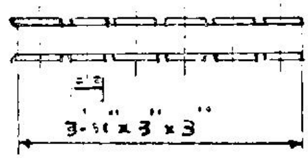
⑤



REVOLVING TRESTLES FOR 4-WHEELER WAGONS 4 No. PER WAGONS

(7)

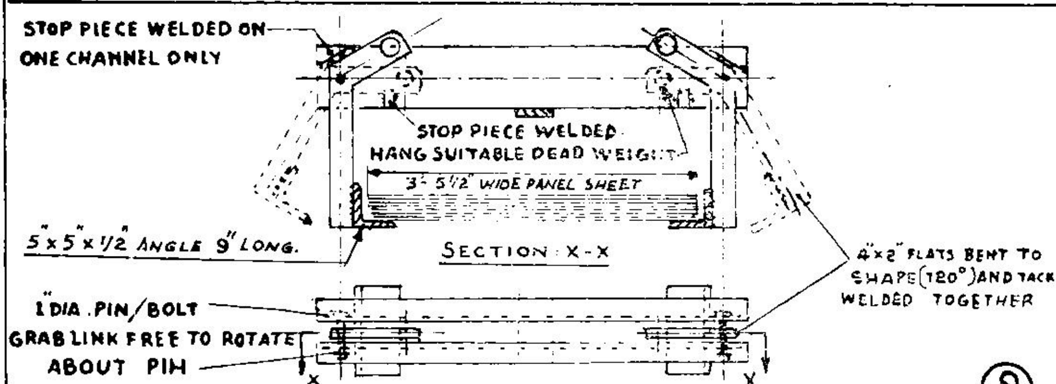




PALLET FORKLIFT TRUCKS.

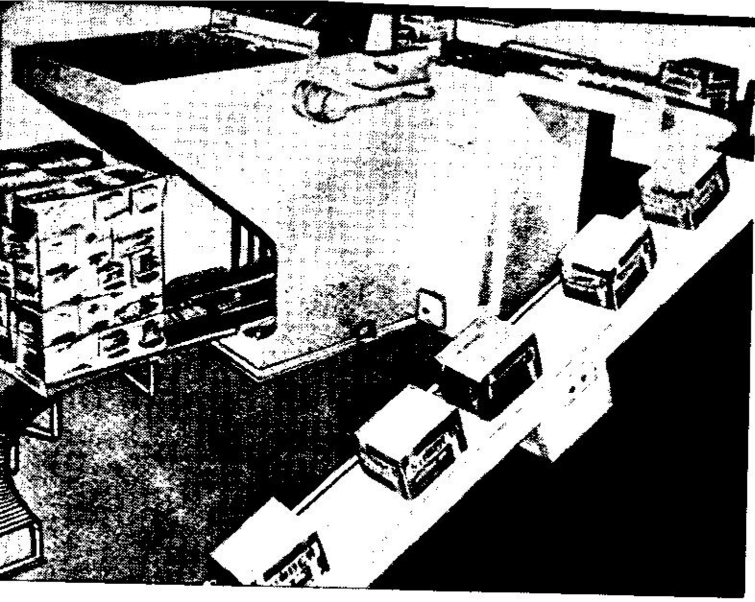
MAT: WOOD

(8)



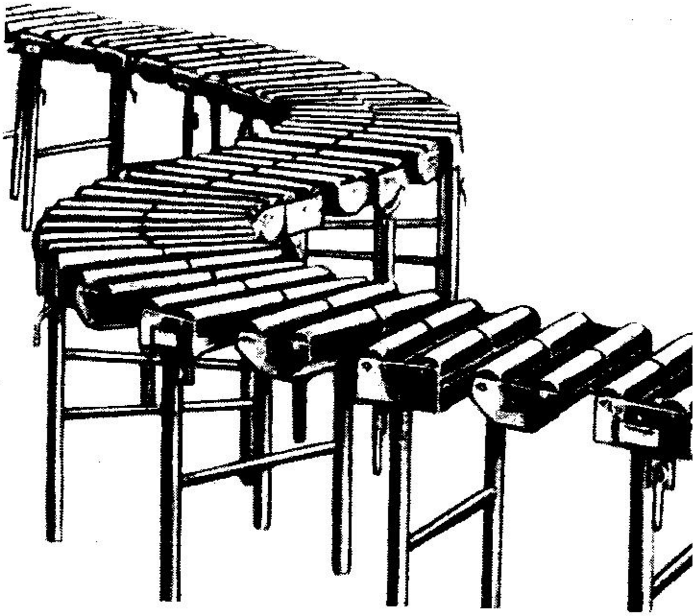
GRAB FOR HANDLING PANEL SHEETS & FLOOR PLATES ETC.

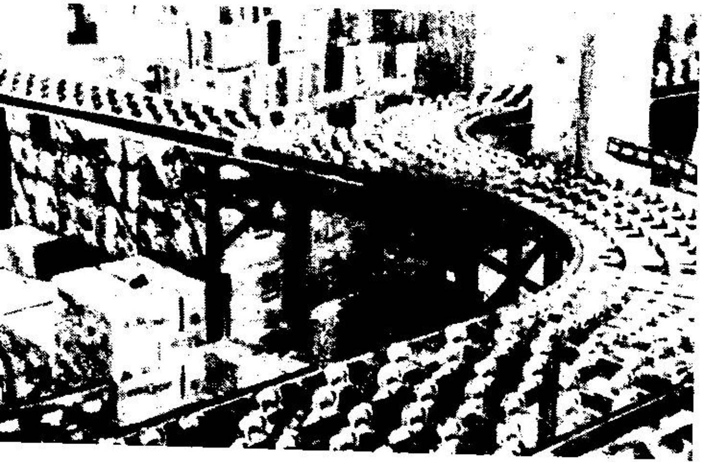
(9)



Automatic pallet loader

Adjustable Curve Conveyor





Wheel Conveyor

Materials Handling Equipment

The number of devices and types of materials-handling equipment are legion. Sometimes it seems as if there are almost as many kinds of equipment as there are materials to be handled. To add to the confusion, there are almost as many classification systems for such equipment. If one, moving stairs or elevators will be classed as 'cranes'; in another, they are, more logically, listed under 'conveyers'. In many classifications, there is a sharp division between equipment for handling liquids, bulk (loose) solids, parts and equipment, and packaged goods. Yet pipelines, traditionally reserved for liquids, are now being used for many finely divided solids; a belt conveyer that will handle parts and equipment will also handle packages, and so on. However, there are four major classes of equipment on which there is general agreement and with which every manufacturer should be familiar. These are outlined below.

By dictionary definition a conveyer is a device used to carry material over a fixed route. The breadth of that definition makes the classification 'conveyer' a real catchall. Among the types of materials-handling equipment classed as conveyers are the familiar moving belts; screw conveyers, which use a propeller-like helical fin or 'screw,' to push materials along; and pneumatic and hydraulic conveyers, which are actually pipelines through which materials are sucked or pumped.

Each of these types has myriad subdivisions. There are flat belt conveyers, troughed belt conveyers, bucket conveyers, metal-salt conveyers, monorail conveyers, gravity roller conveyers, and many others. There are conveyers to handle bulk or packaged materials, small items or big ones; to move parts up, down, or horizontally; or simply to hold them suspended in mid-air. Not every type of conveyer can do every job, of course; or move in all directions. For instance, a screw conveyer will handle only bulk materials—and only those which will not be damaged by crushing—and it will move them in only one direction. *A belt conveyer, on the other hand, can be designed to handle almost anything—even people according to one company which is promoting the idea of using conveyers for mass transportation.* Manifestly, this type of conveyer won't handle liquids unless they are in some type of container.

While conveyers carry materials along a fixed path, this does not necessarily imply lack of flexibility. For example, though the conveyers remain fixed, materials can be directed to any one of several end-points by arranging groups of conveyers so that material can be fed into any one of them by a gate or switching system. Furthermore, the conveyers themselves need not be stationary except while in operation. It is possible to obtain portable, light-weight units that can be moved from one part of the plant to another, and set up as the need arises.

Monorail systems, sometimes classed as conveyers and sometimes considered with hoists and cranes, deserve special attention. These are, essentially, an overhead or underfloor tracks to which can be attached any one of a number of types of hooks, racks, baskets, and *dollies* for transportation of a variety of objects. The overhead monorail conveyers are particularly useful as 'live storage' conveyers. Racks or baskets suspended from a closed-circuit track will simply ride parts around overhead—in space often wasted—until needed, bringing them past the point of use at regular intervals.

cranes, hoists, and grabs

This classification is generally reserved for lifting devices—at least, for devices which, as part of their operation, pick up the material being handled.

Except for small cranes, hoists, and grabs mounted on casters or on crawler tractors, these devices generally are stationary or move along a fixed track. They can be hand or power-operated, and range from the simple jib crane to highly complex and expensive overhead travelling cranes, complete with air conditioning for the operator.

Cranes, hoists, and grabs are especially good for lifting heavy or bulky parts (dies, big coils of steel, loads of lumber, etc.) and for use where aisle space is at a premium—provided there is sufficient room to manoeuver the equipment. However, it is important to remember that the area which can be covered by a crane, hoist, or grab is limited by the rails or trolleys on which it travels or the length of its jib. It is possible, by using switching devices, to carry parts from one room to another, but installations of this type are rather expensive, and the volume of material handled must be quite high to justify their cost.

industrial vehicles

Here are grouped the many types of trucks and tractors developed for plant use. They range from the simple wheelbarrow to powered equipment like fork and platform trucks. All are characterized by freedom of movement—they can go almost anywhere, and, if necessary, in nearly any direction. Often classed separately, and worth remembering in considering materials-handling equipment, are standard motor vehicles and railroad cars. Many of these are used within plant areas, as well as for long-distance transportation.

The industrial truck is, by all odds, the most versatile type of handling equipment from the point of view of variety or materials accommodated and mobility. In addition to the standard fork and platform types, used to pick up unit loads, pallets, and skids, there are a variety of special attachments: single prongs which can be used to handle rolls of paper or metal, special clamps for unit package loads, rotating heads to facilitate dumping of bins, and numerous others. Industrial trucks are available in both guided and driven models, with diesel, gasoline, or battery power; long or short wheel bases; plain or extensible lifts, and so on. In fact, there are at least as many types of industrial trucks as there are passenger automobiles.

In addition, there are industrial tractor-trailer systems which combine a puller unit (an industrial truck or a specially designed tractor) with a train of wheeled *dollies* on which loads—including pallets—can be handled. Less manoeuverable than the industrial truck alone, these systems are particularly valuable for relatively long-distance movement of fairly large amounts of material. They also permit dropping material at several different points, simply by unhooking a *dolly* or two.

For handling material in unit loads (that is, in groups, rather than singly) with industrial trucks, there is a variety of pallets, skids, skid boxes, and special racks. It is also possible to make up unit loads without skids or pallets, and pallets may be used to handle single items.

Basically, a pallet consists of two flat decks, separated by spacers so arranged that forks or prongs can slip in between them to permit lifting and moving of the load. A skid is a single-deck unit with legs or runners near the outer edges so it may be picked up by a platform truck. Single deck units with pallet-type spacers acting as legs are also available. They are sometimes called pallets, and sometimes skids.

A unit load, as we have indicated, is a group of parts, products, or packages, fastened together for handling as a unit—with or without a skid or pallet. The advantage of the unit load, of course, is that many items can be handled as one. The pallet forms a natural base for such a load, but it is possible to make up and handle a unit load without a pallet or skid. Sometimes, runners can be attached to the bottom of the load itself; in other cases spaces can be provided within the load for entry of truck forks. The normal method for holding unit loads together and for keeping products on pallets or skids involves steel strapping, industrial tape, glue, or rope.

Unpalletized unit loads do away with the necessity for returning the pallet to the point of shipment. However, use of such loads is limited to certain types of products. Another way to get around need for returning pallets is the use of 'expendable' pallets—relatively low-cost cardboard units .These, too, however, have certain limitations.

While skids and skid boxes are still widely used, and unpalletized unit loads have special applications, pallet-handling is today the most popular method. The savings in time, effort, and actual cash which can be achieved through proper use of pallets are remarkable. One furniture manufacturer, for instance, adopted pallet-handling and cut his handling costs in half. A can manufacturer reduced car-loading time from 2½ hours to less than 1 hour by palletizing cans instead of handling them singly.

Savings like this explain the mushroomlike growth of pallet-handling in recent years. In 1939, only 16 companies made pallets. By 1950, there were well over 1,000 producers. By 1954, annual output rose to over 20 million wood pallets besides a good many steel, wire, and cardboard ones as well. In 1962, a hundred million would probably be not very much of an overestimate.

Conveyerisation

Conveyers are not the only kind of fixed path equipment, but they are the main kind. Cranes travelling on overhead tracks are also frequently used. Elevators are common for vertical transportation and chutes for combined vertical and sloping moves. Pipes tubes, and ducts are often used in handling bulk materials (liquids, powders, and granulated materials). But the main characteristic of modern industrialization is conveyerization.

BIG COMPANIES ARE USUALLY HEAVILY converyerized. Chryslder's Ply-mouth plant in Detroit has over 27 miles of conveyers. They move parts to 1,600 machines for fabrication and to men using 1,900 hand-power tools in assembly work. GE's Hotpoint electric stove factory in Chicago has nearly 2 miles of conveyers. A few are for storage to balance operations where some operations operate two shifts and other three.

Conveyers move enormous quantities of materials at low unit costs. Generally they move slowly, but some operate at high speeds. Trough belts can transport bulk materials at over 600 feet per minute, and the large ones used to transport ore move over 6,000 tons per hour. One such belt used to transport ore is over two miles long. Another, which is inclined, raises 1,200 tons of coal an hour to a height 860 feet above the level at which it is loaded. Such lengthy conveyer hauls are not usually made on one single conveyer but on several successive conveyers, each dumping its load onto the next one.

Belt conveyers handling other types of materials often travel 100 feet per minute and are sometimes run at twice that speed. When used for picking, sorting, or supplying materials to operators, conveyers usually run at a speed of 10 to 50 feet per minute. Conveyers used for an operation such as cleaning, painting, baking, drying, and cooling move very slowly, perhaps from 2 to 6 feet per minute.

Slowly moving overhead conveyers are sometimes used for temporary storage. They are out of the way and can hold substantial bulk of materials. Both overhead and work-level conveyers are frequently an integral part of the producing process, an operation often being performed automatically or by a worker as the conveyer moves the material along. Painting, baking, cooling, cleaning, degreasing, electroplating, washing, and many other operations can be done in this way. Conveyers are also frequently used to move materials to and from automatic sackfilling and canfilling machines.

Vibrating and oscillating conveyers are metal troughs which move a short distance toward the take-off end, jerk quickly back toward the feed end, and then repeat. They are sometimes used for short distance horizontal transportation—up to 100 feet, usually much less. The movement is rapid, hence the terms. Vibrating conveyers jiggle 1,000 times a minute or more; oscillating conveyers 250 to 300 times per minute. The effect is to move material steadily to the take-off end.

There are several other special kinds of conveyers. Belt conveyers with non-slipping slats or cleats are sometimes used to convey packages to upper floors. Bucket conveyers are frequently used for bulk materials, as are screw conveyers, which, when set at an incline, provide efficient transportation up or down. Enclosed screw-type conveyers can easily hoist 50 tons of material an hour, and bucket conveyers can handle even greater quantities. Twin screws, unenclosed and turning in opposite directions, are sometimes used for moving sacked materials.

automatic transfer conveyers

Automatic transfer machines use conveyers. Products are fastened down in exact position onto the conveyer at one end. It then moves a fixed distance (to the first machine) and stops while one or more machines do their work. Then it takes the product onto the next workstation when it stops again. This is repeated until the product comes off at the other end all machined and ready to use. The conveyer is a most important part of this process, but it takes a back seat in our thinking to all of the automatic machines that do the operations.

Guide to Selection of Handling Equipment*

RICHARD MUTHER

Purpose		*Type of Equipment*
Use conveyers	Where unit loads are uniform. Where the materials move, or can move, continuously. When rate of movement, unit loads, and location of route are not likely to vary. Where cross traffic can be by-passed by the conveyer.	Types of conveyers include gravity, roller, wheel, spiral, live roller, belt, chute, trolley chain, floor chain, apron, pusher bar, vertical tray, reciprocating, pneumatic, automatic, and portable.
Use cranes or hoists	For intermittent movements within a fixed area. Where materials are of variable size or weight. For movement of materials free from concern about cross traffic on the ground or variation in load.	Hoists are commonly divided into three classes: chain, air, and electric hoist. The electric hoist has the widest application since its high speed results in economic operation. Common types of cranes are the portable crane, the jib crane, the derrick, the gantry, and the overhead travelling bridge crane.

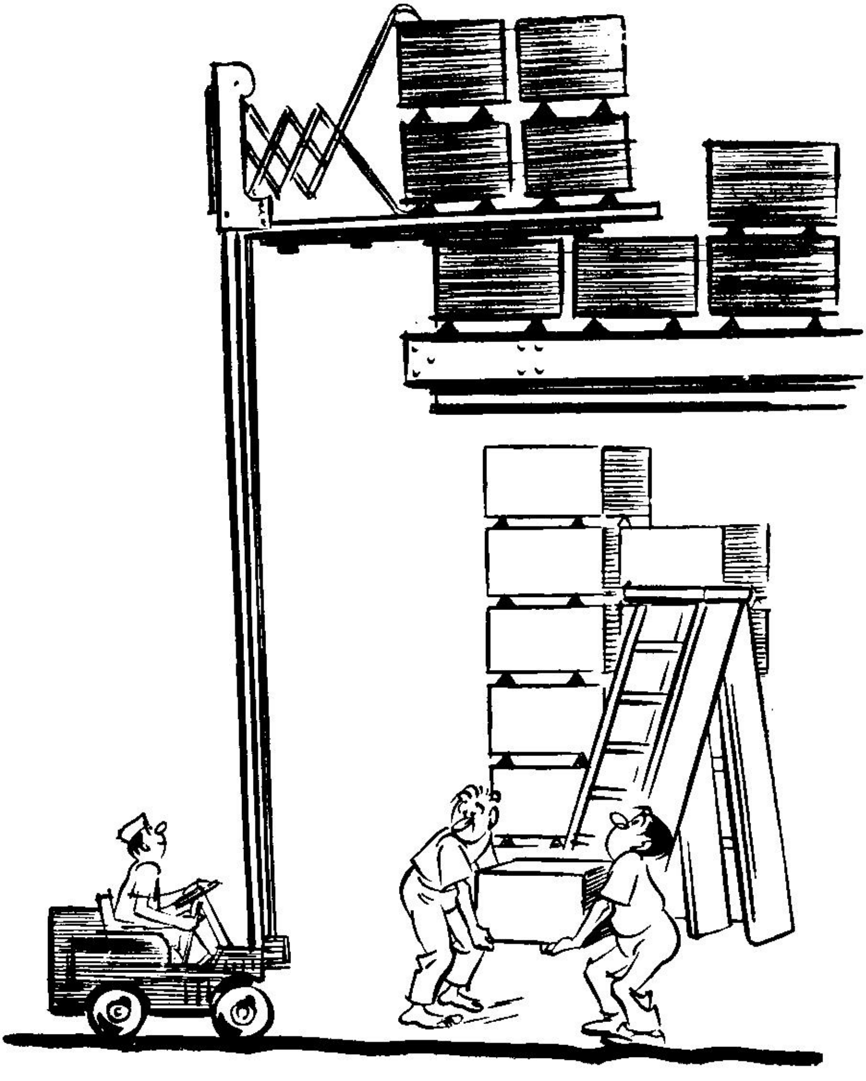
The prime function of the hoist and crane is lifting.

Use industrial trucks	Where materials must be picked up and moved intermittently over various routes. Where materials are either of mixed size and weight or of uniform size. Where distances are moderate. When cross traffic exists. When there are suitable running surfaces and clearances.	Industrial truck equipment can be broken down into hand-operated trucks, tractors, platform, high and low lift-trucks, and fork trucks. Trucks are further classified by their power source: (1) battery electric, (2) gas electric, and (3) gas mechanical. Tractor-trailer trains may be selected where the

*Adapted from publication by the *General Electric Company*.

Where the operation is principally handling. Where unit loads are utilizable.	conditions prescribed for the industrial truck are met, but where horizontal transportation over greater distances is the main requirement.

There are many adaptations of industrial trucks each designed to accomplish a specific type of job. They are so flexible in operation that the integration of the industrial truck system with the crane or conveyer system satisfactorily answers most materials-handling problems.



Ropeways

ROPEWAYS ARE USED FOR OVERHEAD TRANSPORT OF MATERIALS WHERE GREATER DISTANCES are involved. Ropeways consist primarily of cars, platforms, grabs or cages operating on cables supported at regular intervals by sheaves mounted on towers of pylon. Loading and unloading may be manual or automatic and will vary according to the materials being transported and the type of operations involved. The general type of ropeways are:

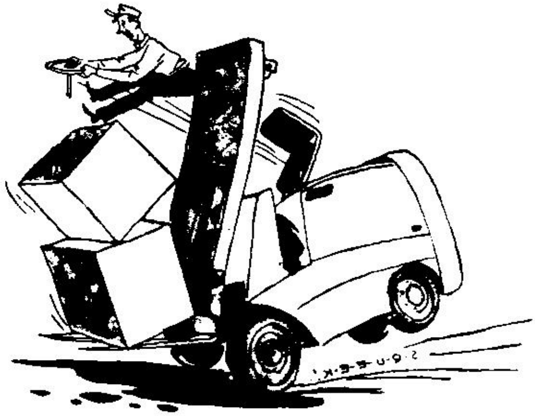
monocable systems These systems have one rope which sustains the load and propels it. Because of this double duty the system is suitable only for light loads and small hourly capacities. They are also limited in gradient unless special gripping carriages are provided.

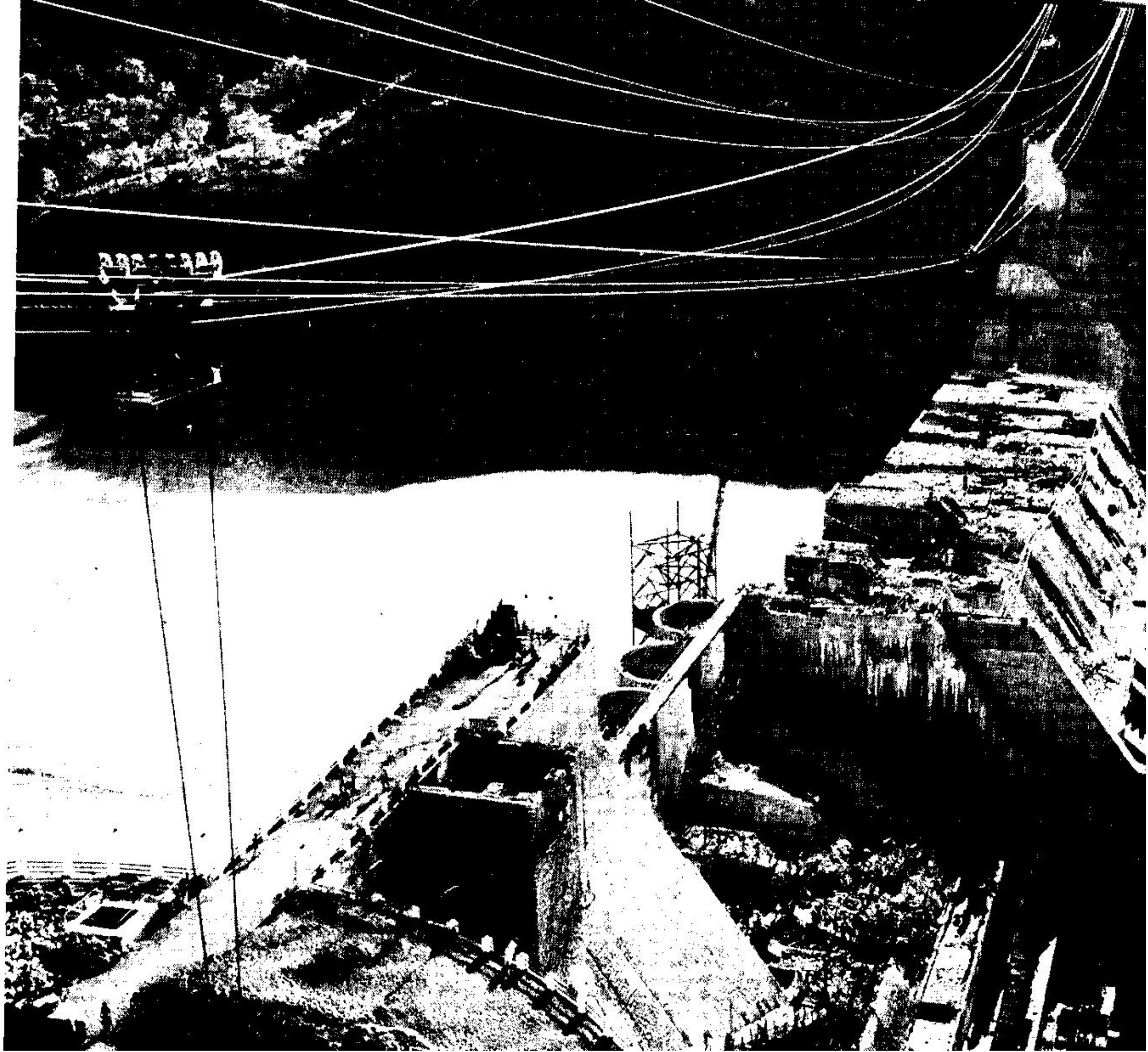
bicable systems In these systems one cable is used for propelling the load and another cable is used as a rail upon which the cars travel. They are used for heavy-capacity long-length installations and may be operated at steep inclines.

double-track system The double-track system uses four-wheel carriers running on a pair of supporting cables for tracks. Another cable tows the carrying along. Carrying and return runs are located above each other or side by side.

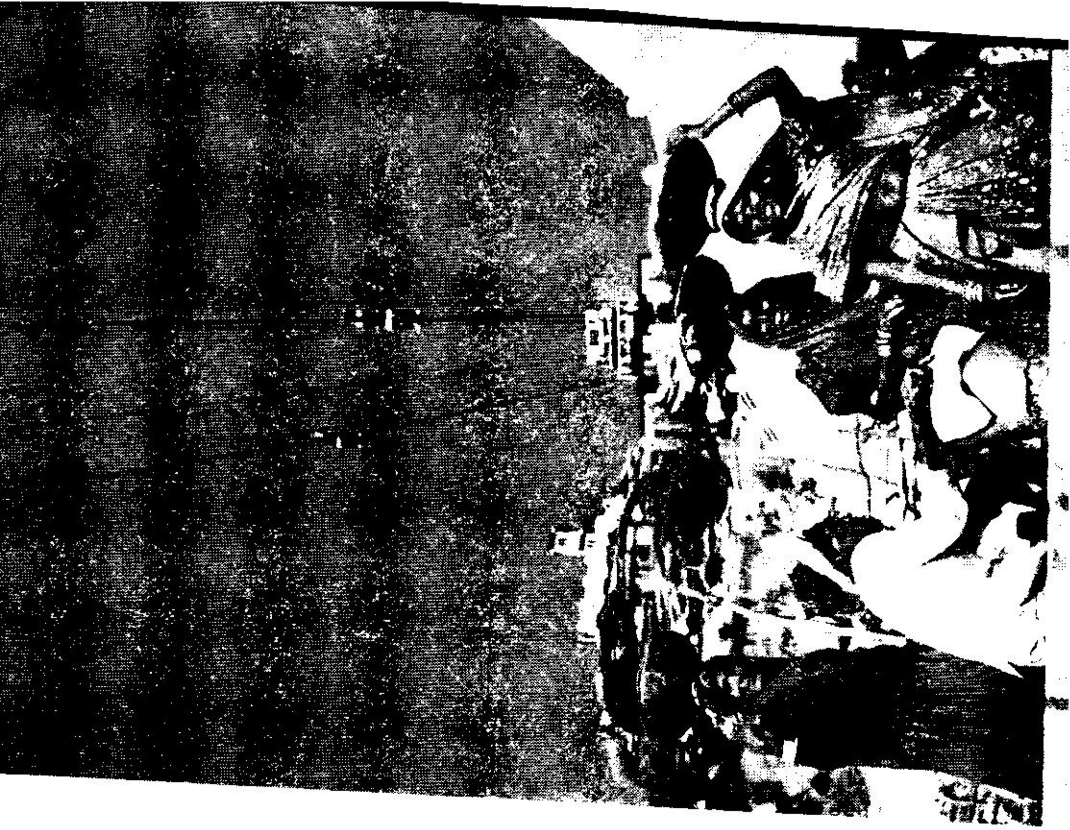
shuttle system This system carries buckets or cars to a discharge point and returns operating in the manner of a balanced skip hoist.

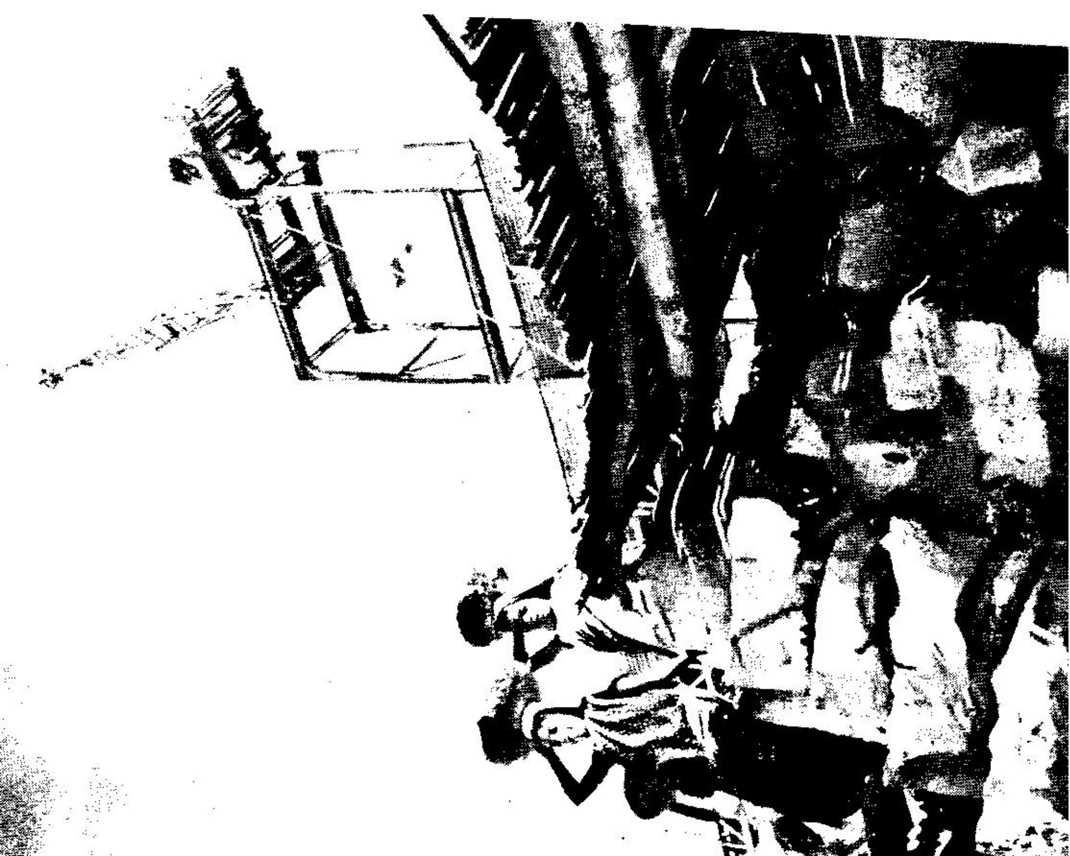
jigback system This type of system provides for the automatic discharge of the contents of the bucket when the direction of travel is reversed. Jigback systems are generally used to cover only short distances.





CABLEWAY
CHANDAN
SAGAR
DAM
CHAMBAL
VALLEY
PROJECT





MODERN HANDLING EQUIPME

PL KUMAR*

IN A PRODUCTION UNIT A PRODUCT PASSES through 8 handling movements ches the consumers. These are: (1) the procurement of raw ma source (2) transport to factory store (3) in the factory prior to use (4) inter-process handling including inspection (5) packaging and sealing of (6) factory storage prior to despatch (7) despatch to port or inland station (8) to consumers. It is important that this non-productive cost should be ke minimum possible and the use of scientific materials-handling equipment in would help to reduce these costs and raise productivity. The use of effort in handling cannot be considered very economical if we appreciate that it Human body of European build produces a physical effort of approximately 1/8 hour; in our country it would be about 1/16. Its value can be appraised again that it costs about 6 nP. per H.P. per hour for generating same energy by electric

Handling represents a major part of cost of production. Figures are not of the total wage bill which form the cost of materials handling in our economy, bu from the statistics of an industrialised country like the UK where the wage bill the manufacturing industry was of the order of £3,830 million, it is estimated cost of materials handling amounted to almost one-third, about £1,300 million. country, where the pattern is different in so far as the scientific means of handlin much known, or are little employed the handling costs would form even a higher than in the UK of the total cost to the consumer.

It would appear, therefore, that there is considerable scope for lowering the cost of the manufactured goods to the consumer by reducing as far as possible the ductive cost of handling by the use of scientific handling devices and equip technological advance has been made in this respect in the industrialised countries the use of cranes of various designs, hoists, conveyors, fork-lifts, auto-trucks, bulldozers, tractors, crabs, chutes, etc.

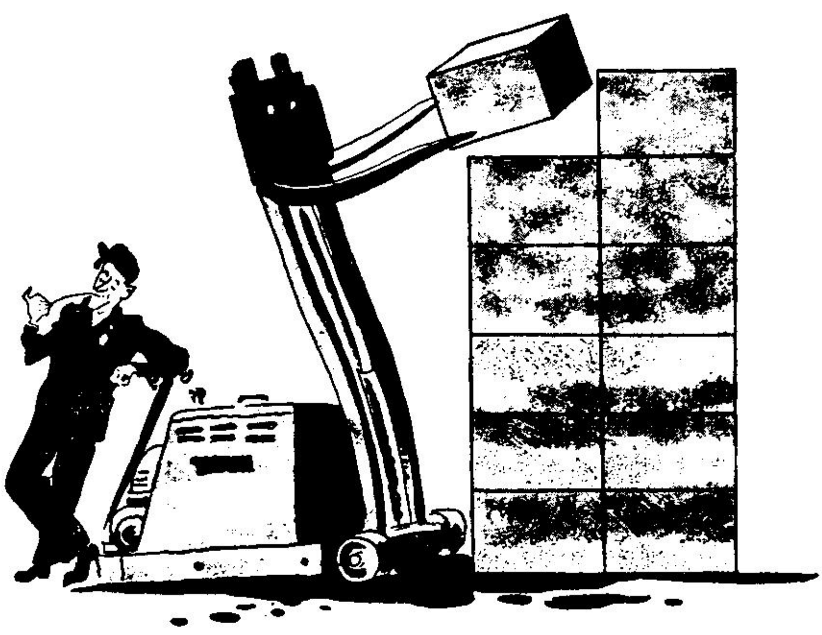
In India, however, we need not necessarily follow the practices adopted in countries. Our circumstances are somewhat different, for we have surplus la study has to be made from the angle of our own economy. When studying the of handling equipment, it may be remembered that the modern handling equi assists in making the use of the vertical space in a factory. For instance, it was the olden days to stack barrels or containers at a great height, but the use of conveyors nowadays can allow these materials to be stored almost upto the ceiling in a factory. This aspect also effects considerable saving.

Take another case of the Lignite Project which could not be completed wi sonable time to give the benefit to our State without the huge earth movers,

*Amalgamations (Private Ltd.) Madras.

which are now being employed. It would be impossible to have mass production in certain units without the handling equipment being installed. As an instance, a sugar factory which handles 500 tons/2,000 tons of sugarcane per day could not be operated without handling equipment. Similarly, it would be impossible to manufacture steel in a large unit producing a million tons of steel per year without proper handling equipment being installed, which has to handle nearly 12 to 15 thousand tons of raw materials each day. Nuclear Research could not have been possible, had it not been for the invention of equipment for remote handling of radioactive raw materials.

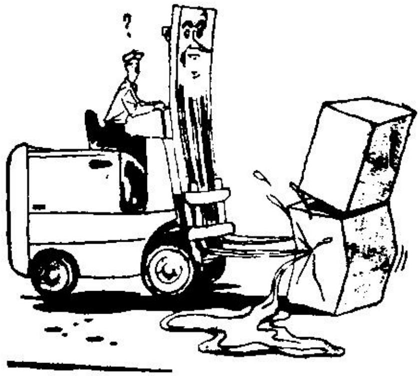
Handling equipment helps to have quicker turn over and maximum output. In fact in our own country, it would not be possible to export large quantities of manganese and iron ore unless we have provided our ports with uptodate handling equipment. In this regard it may be noted that a port in West Bengal is being equipped with the most modern handling equipment to be able to cope up with the iron ore which we have to export to Japan under a long-term agreement.

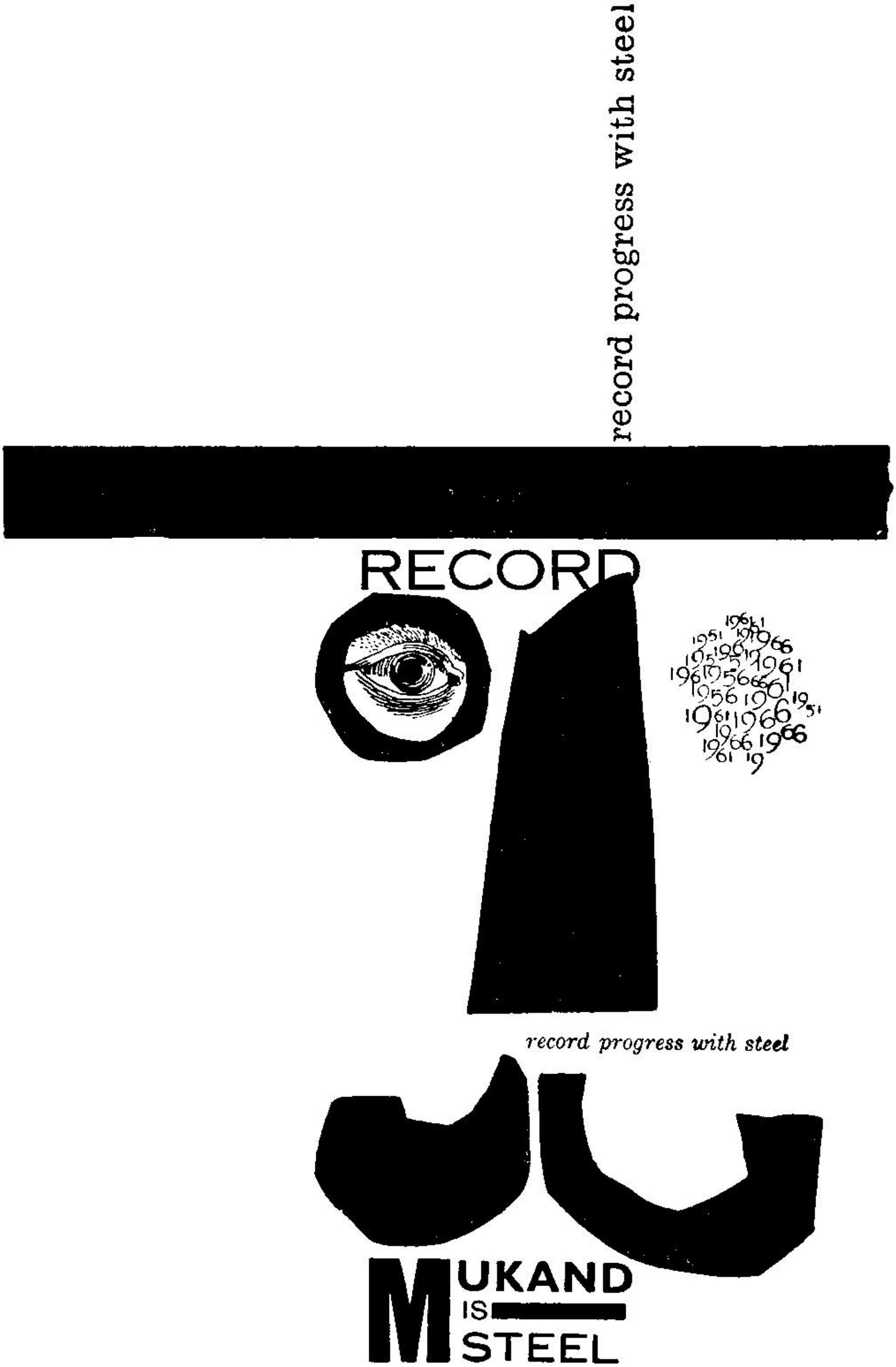


Materials Handling Industry in India

In a large and direct way, India has hardly made a beginning in the manufacture of materials-handling equipment, on a scale commensurate with the requirements of a full-fledged industrial economy. Nevertheless, there are as many as 143 firms producing steel structural with a total installed capacity of about 4 lakh tons per annum. In addition, some more schemes have been licensed and the projected capacity would be about 7 lakh tons per annum by the end of the Third Five-Year Plan period. The actual production in the past has, however, been less than the installed capacity primarily in view of the shortage of steel sections, particularly 'matching steel' and we have serious difficulties in several directions. We have, for example, no firm manufacturing complete ropeways. This information may be outdated, for there are firms now interested in making ropeways. In fact, with aggregate demand exceeding aggregate capacity over the whole range of industry, we can, through proper planning, bring whole new industries into being, catering to the materials-handling requirement of a vastly expanded industrial sector, called upon every moment for a larger and larger output. This can only be done through a massive increase in the availability and efficiency of materials-handling equipment.

The need, for example, for electric overhead travelling cranes and dockside cranes has increased immensely, due to rapid industrial activity in the country. The existing installed capacity of 7 firms comes to approximately 12,000 tons per annum. An additional 9 thousand ton capacity has been licensed, making a total of about 21,000 tons per annum. As against this, the target demand for cranes by the end of the Third Plan period has been assessed at 60 thousand tons. This in fact is the story in respect of all materials-handling equipment. Our earth moving programme would warrant the setting up of whole new industries, manufacturing shovels and draglines, tractors, motorised scrapers and dumpers and the like alongwith their myriad attachments ! Some firms have been licensed, but we are yet a far way behind and an infinite volume of employment can be created through creation of additional capacities for the manufacture of materials-handling equipment, their maintenance and operation.

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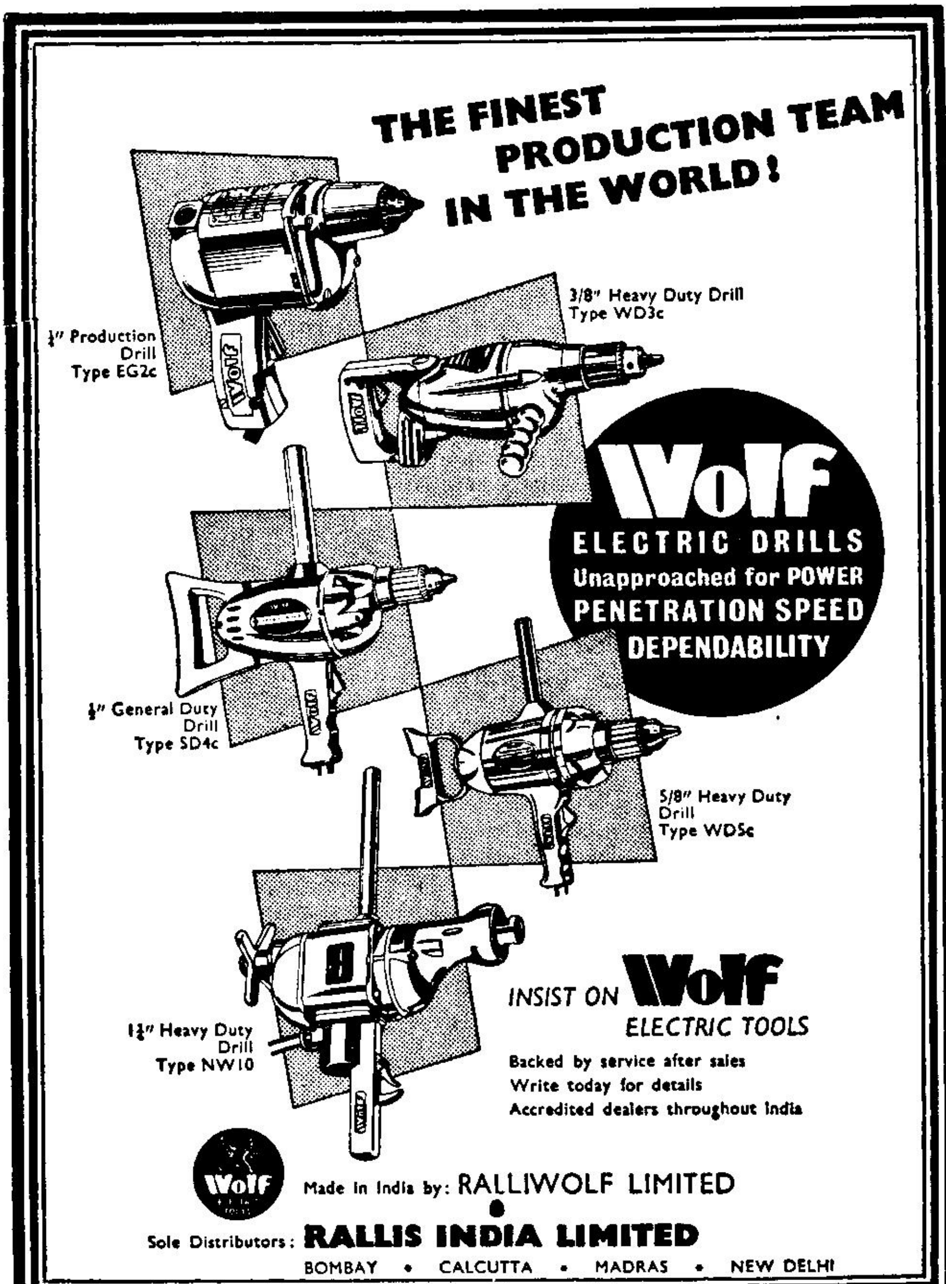
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Materials Handling at Madras Port

VA JAYWANT*

The process of handling of materials in any industry deserves very close attention of the Management as any damage, slowness or awkwardness, while removing the materials from place to place, is likely to affect the outturn of the establishment, the quality of the goods produced and consequently affect not only the finances of the organisation but also may create a bad impression in the minds of the general public who use the products produced.

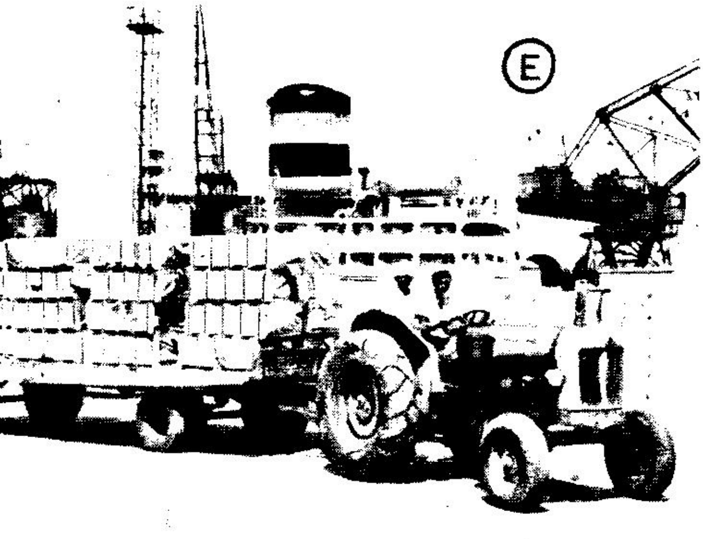
A PORT IS ALSO AN INDUSTRY WHERE THE production is materials handling itself, unlike other industries where raw materials are moved from place to place till they are made into finished products or the finished products are moved from the production line for packing and storage wherefrom they are moved to the consumer. In a Port, the very function of the Port authorities is materials handling. The main functions of a Port are: to receive cargoes arriving for discharge, remove them from the landing point or hatchway to a suitable stacking or storage place, stack them properly and deliver them to the consignee when he comes forward. The same procedure in the reverse way is the method as regards export cargo. That is, we receive the export cargo for storage in the shed, store it properly and remove it carefully to the loading point, prepare the sling and hook the sling without any damage to the cargo.

The Port of Madras handles various types of imports and exports: various types in packing as well as in commodities. The normal method of handling of packaged cargoes is manual. That is, the small cased or crated or bagged cargoes, landed on the quay, are loaded by labour on a hand barrow, taken to a suitable place where that type of cargo can be stored and there the cases or crates or bags are lifted from the hand barrow and stacked properly according to marks and contents. The wheels of the hand barrow are rubber-tyred and are provided with ball bearings which are helpful to avoid damage to cargo. Labour also finds it very convenient to use them. The above procedure in the reverse way is adopted in the case of export cargo. This is the usual method adopted at practically all Indian ports and in most of foreign ports which have not been mechanised.

The heavier packages, which normally cannot be lifted by labour, are lifted by means of mobile cranes at the landing point and removed to the stacking or storage point by the crane itself or if the distance is longer, the packages are put on a four-wheeled truck which is towed by a tractor to the place of storage (*photograph E*) and a crane is used again there to take off the packages from the truck and stack them where they are to be stored. There are cranes of differing capacities, ranging from 3 to 10 tons and they are mobile.

We have recently, about four or five years back, introduced the mechanical equipment for movement and storage of cargo especially from the landing to the storage point. These equipments are what are called 'Fork-lifts' and our experience is that with the different types of gadgets which can be attached to

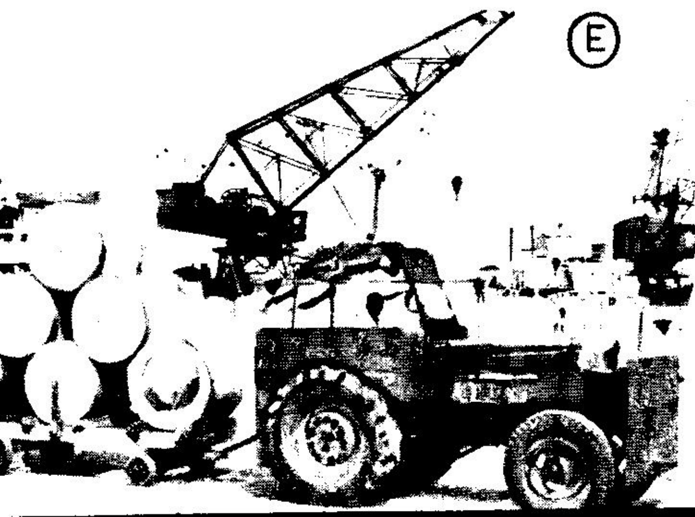
* Traffic Manager, Madras Port Trust.

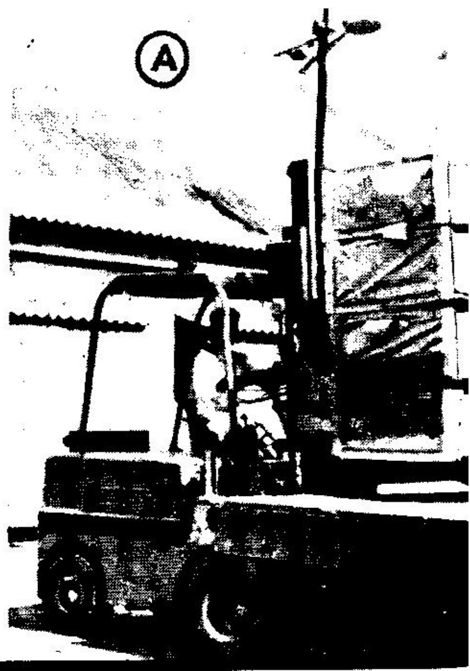


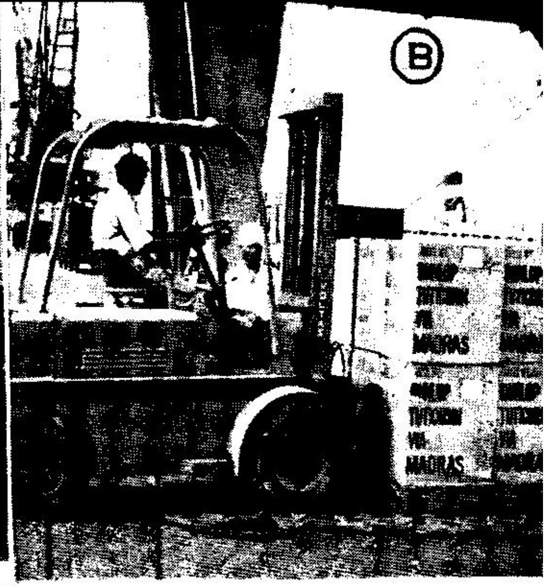
HANDLING

AT

MADRAS PORT



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these fork-lifts, movement of cargo for short distances and stacking them becomes easier and helps to reduce the labour workload. It results in handling of the package without any damage to the contents. Moreover, it helps to store more cargo in a given place. The fork-lift can stack cargo as high as 14′ normally and it can be used to advantage fully exploiting air space for storage.

There are fork-lifts of various capacities and similarly, there are various types of gadgets also for handling different types of cargo. We normally use the squeezing type of attachment (*photograph A*) for handling reels paper, bales cotton, bales gunny, drums, bales hides and skins etc. The fork-lifts with the normal forks are used for handling of small cases, cartons and other ordinary packages (*photograph B*). If pallets are used in conjunction with the fork-lifts, storage of homogeneous types of cargoes becomes very easy and the storage capacity in a given square area also gets increased considerably (*photograph C*). At the Port of Singapore, almost all types of cargo excepting loose bulk cargo are stacked with the help of fork-lifts and pallets.

Along with the fork-lift if another equipment called the "platform truck", is used, the turnover of a fork-lift can be increased. These trucks are battery-operated and the platform of these trucks can be raised or lowered by a few inches, which gives enough room for the stillages being used. These trucks can be used for feeding the fork-lift at the stacking point (*photograph D*). Just as a fork-lift or platform truck can be used for movement of smaller packages, with or without the help of pallets, four-wheeled ordinary trucks of different capacity and various types can be used for transport of bulky and heavy cargoes from place to place (*photograph E*). In the Port of Bristol, they have small four-wheeled trucks, which are formed into a train of 10 to 15 trucks and drawn by a tractor. About 30 to 40 tons can be moved at a time from one warehouse to another without causing damage to cargo and at the same time moving it in a faster way.

An NCDC Experiment in Coal Loading

SK Bose*

Nearly half of direct production problems in mining relate to transport. At the coal face underground, the problem of transport becomes very acute as a regular quantum of mineral has to be transported from the working face which is changing its position every day and every shift and whose progress is greatly influenced by geological and mining uncertainties...In coal industry, the problem of transport of coal at surface despatch end is again very unhappy. Here, it is in another way. The point of despatch is fixed but availability of rail transport for coal is extremely fluctuating and uncertain. This position of uncertainty has badly hit the coal industry since the second world war..In this article, a short description is being presented indicating how the *National Coal Development Corporation* has made a direct approach in designing and introducing a completely novel system of storage for coal in different sizes for subsequent loading on railway wagons in part rakes. One happy point in this venture is that the various stages of planning and layout, erection of equipments and trial running have all been done directly by engineers of NCDC.

Coal coming from mechanized opencast mine is first crushed to about 200 mm size before it is elevated to the screening plant hopper. The underground coal conveyer directly feeds the screening plant. There all coal is screened into 3 fractions—slack, rubble, and steam coals. The slack and rubble fractions directly and steam coal after necessary picking of stones go on to the 3 different pockets of a large ground bunker. Alternately, steam coal after picking can also go directly to an independent wagon-loading point.

The ground bunker is so positioned and designed that a common high capacity 42″ reclaim belt conveyer can directly load wagons with one type of coal at a time. There are vibratory feeders fixed below the bunker for feeding coal on to the reclaim belt conveyer. At the wagon-loading point there is a weighing machine on the belt and a two-way chute is placed above wagons so that wagons are loaded without spillage. During loading, wagons are moved by wagon haulage. The idea is that wagons are loaded with their respective pay load capacity, minimising subsequent adjustment of wagons.

In building up plants on these layouts *we have used only indigenous machinery* except the vibratory screens and feeders. In this process, NCDC has been instrumental in promoting indigenous manufacture of machinery. At present NCDC is constructing 3 plants of almost similar type, of which one has started functioning and two are in the final stages of erection of equipments. Two of the plants are completely designed by NCDC and in one plant, the

*Dy. Superintendent of Collieries (Planning), NCDC, Ranchi (Bihar).


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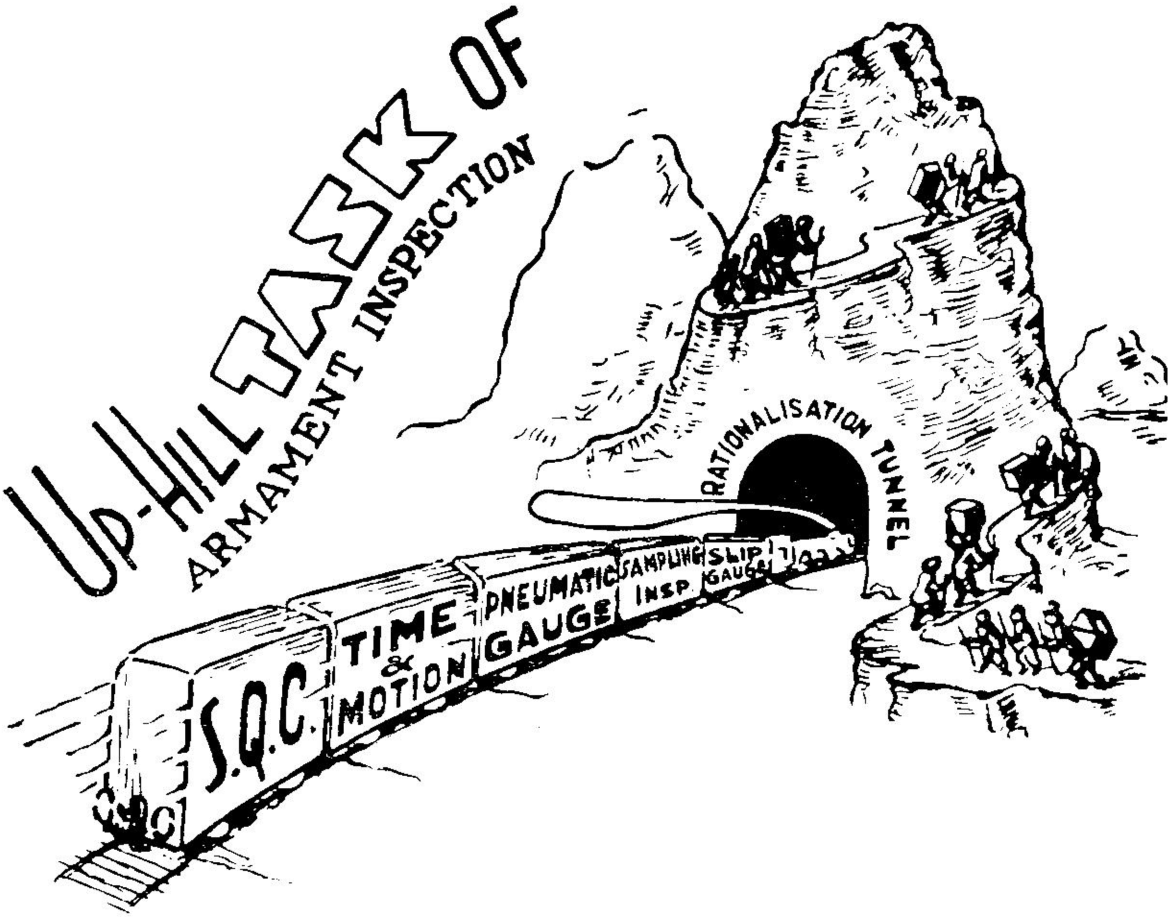

Up-HILL TASK OF
ARMAMENT INSPECTION
RATIONALISATION TUNNEL
S.Q.C.
TIME & MOTION
PNEUMATIC GAUGE
SAMPLING INSP.
SLIP

civil design portion has been prepared by an Indian consultant.

For a mechanized mine, designed to produce 4000 tons a day, the self-flowing capacities of bunker pockets are 3400, 600, and 2300 tons, respectively, for steam, rubble, and slack sizes of coal. The capacity is highly flexible and can easily be expanded by addition of tractor shovel etc. Wagons can be loaded at the rate of 400 tons per hour.

Variations at surface end of coal movement in colliery has led NCDC to adopt bunker arrangement at wagon-loading end. With priority for different sizes of coal being different, capacities of bunker pockets in terms of day's output were also made different. For this reason, while bunker capacities for steam and rubble sizes were kept at about $1\frac{1}{4}$ days' output, the slack coal bunker had capacity for about 3 days' output. Apart from this, sizes of rakes in relation to destination were also kept in view. It was considered desirable to have bunkers after screening of coal so that stocks inside bunker would be available ready for wagon loading. This permitted high speed loading of wagon and loading rakes with any one quality of coals, which were essential in block rake loading. To safeguard production in case of breakage of screen, it was considered desirable to introduce stand-by units. There is a screening plant with 3 large double deck 180 t. p. h. capacity vibratory screens. This is inclusive of 1 stand-by unit.

Ground bunker arrangement was preferred to overhead bunker for certain considerations. For large capacity required for rake loading having possibility of loading one quality of coal at a time, and to develop a method to load wagons to their respective pay load capacity, some form of bunker on the ground with belt conveyer loading of wagons was found to be more economical than overhead bunker above track.

One important feature in the design was that length of bunker was kept moderate, in spite of high tonnage capacity. Thereby cost in civil work and additional conveyer were reduced. One interesting feature noticed was that when height of a coal heap was increased from 20 to 25 ft., the capacity of storage increased from 355 tons to 846 tons. But when height of coal increased from 40 to 45 ft., the storage capacity increased from 2,836 tons to as much as 4051 tons. This character of storage tempted the planner to pile up coal from good heights so as to gain good storage capacity and at the same time, excess height would not lead to severe breakage of coal. To reduce breakage, coal was lowered into bunker by means of open spiral chute, lined with chilled cast iron plates.

In order to reduce the capital cost, the bunker was so designed that part of the coalstock became self-flowing and the remaining portion static. By occasional bulldozing, the static portion could either be extended to adjacent ground permitting great flexibility in capacity or could easily be fed into the bunker. This arrangement needed employment of some mobile machine at least when occasion demanded. In open cast mine project, such facility was not difficult.

This provision for flexibility in capacity is essential in storage design for coal-mines. Statistical studies for last 5 years indicate that in Bengal-Bihar coalfields, average pit-head coalstock is as much as 22 days' production. When this figure is broken up into quality wise figures, stock becomes 9, 11, 14, 38, 69 and 80 days' output, respectively, for Sel. A, Sel. B, Gr. I, Gr. II, Gr. III A and Gr. III B coals. In view of this position, any coal bunker in mines needs be designed for two purposes to match the wagon supply variations. First, the bunker must be able to face the day-to-day variation and should be capable of loading rakes of wagons at fast speed. Secondly, enough capacity for ground stocking of coal must be provided for in relation to statistical figures. Our newly introduced layout caters for both the requirements under one installation.

Materials Handling at TISCO

WE IN OUR COUNTRY, NOT DISCOUNTING those all over the World, are fully aware of the tempo of industrialisation in India. In the near future India will enter national and World competitive market condition. To be able to do so like every other nation the industrialists whether in the public or private sector will have to abide by the law of mechanisation on the production line. Automatically, materials-handling operation will have to be mechanised to fall in line. For India, considering the availability of the massive labour force and our rate of production of capital and consumer goods, path to future industrial development can best be taken the mechanised way. The non-stop scientific research and designing of materials-handling equipments has conclusively proved that there is a machine to replace efficiently almost every manual operation.

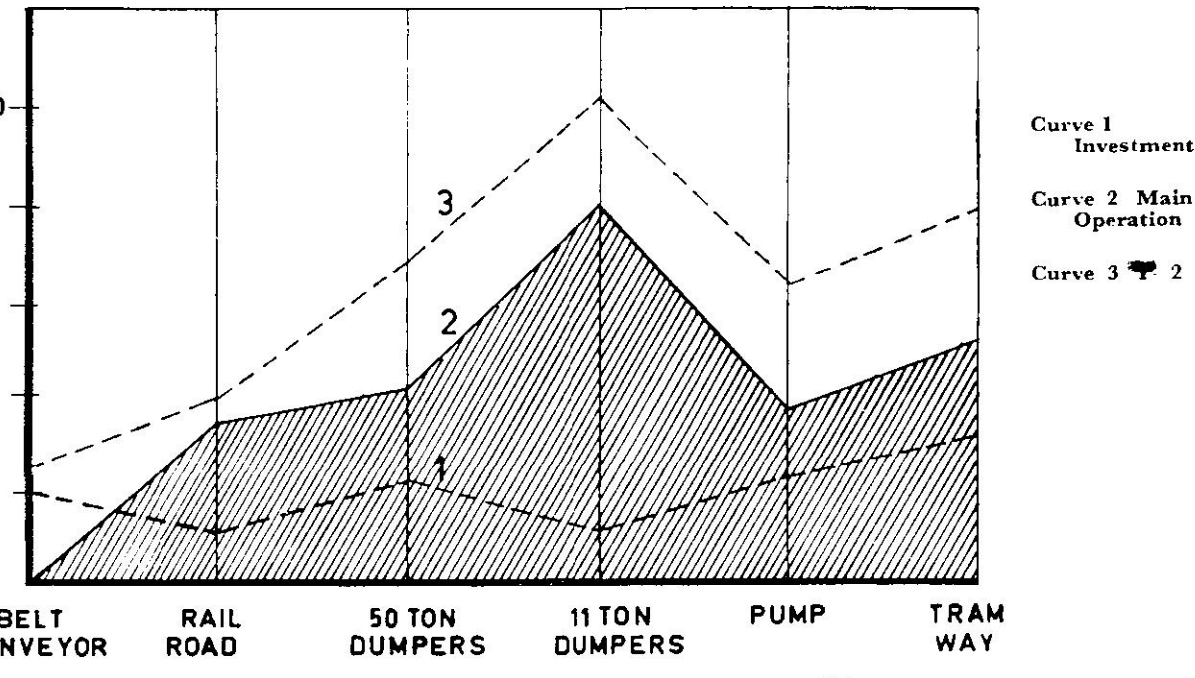
We have in our country today outstanding examples of mechanised materials-handling practices which can be compared favourably with any of the Western countries, such as the bulk materials handling at Nievelli and most of the company-owned iron ore mines in the private and public sectors. Mechanised materials-handling practices on the shop floor are exemplary in industries such as Telco, T.I. Cycles, Indian Telephone Industries, Hindustan Machine Tools and many others which have developed in the recent past. Still compared with what one sees in the Western countries in the way of large scale mechanised materisals-handling practices, we are way back. It is reckoned that today in our country in most of the existing industries 50 to 80 percent of the finished product cost is directly attributed to the cost of materials handling from raw material stage to the finished product. To be competitive in the world market this percentage will have to be reduced by mechanisation as has been done and proved by the industries cited above.

In view of soaring labour costs, the Western countries give just as much or more consideration to mechanised materials handling as to other phases on the production line. It is more pointed in USA where a visitor would think that the country has touched the very limit of mechanisation, though their engineers still continue their progressive development on mechanical materials-handling devices. The one outstanding practice in USA which represents 1/3 of the reduction of the materials-handling cost is the container cargo system. They have developed road, rail, and sea borne equipments specifically designed to handle container cargo in units of 5 to 40 tons. This method has reduced the Cargo handling time and cost from 6 days to 6 hours and 16 dollars to 2.25 dollars per ton of loose and container cargo respectively. The cargo containers are moved by articulated trailer units and on specially designed rail-road wagons and loaded in specially built ships which have a built-in cradle crane to receive and discharge the cargo.

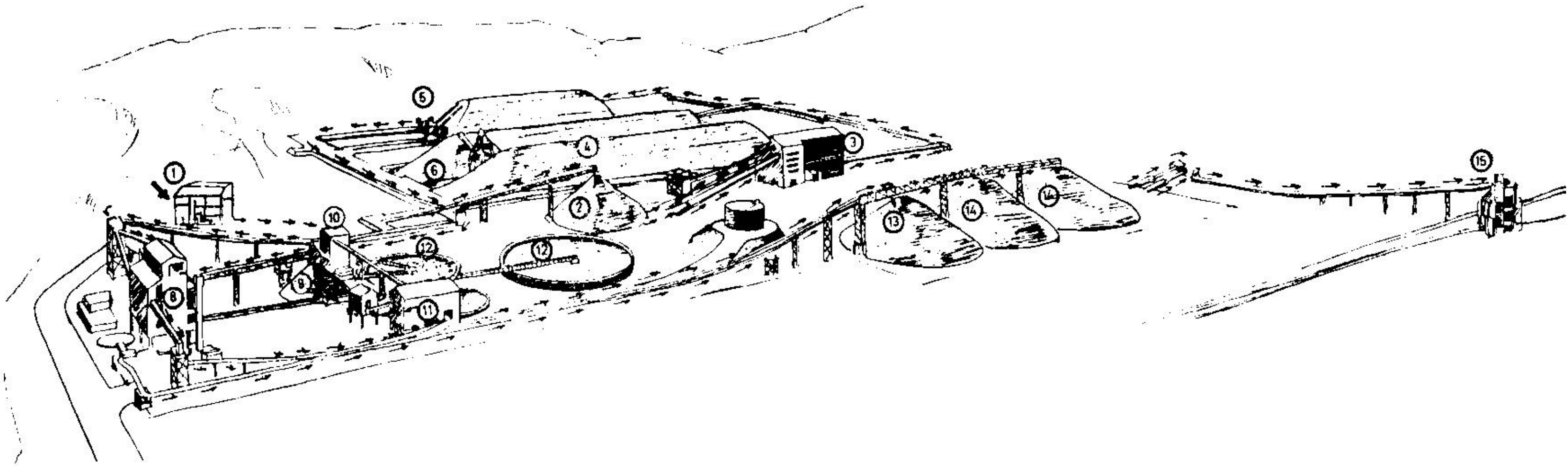
The other mode of materials-handling practice which is outstanding in the USA is palletisation of almost every type of suitable material handled in their heavy and medium industries where straddle carriers and fork-lifts play a significant part. Taking just one commodity such as refractories and bricks, millions of which are handled in major industries and industrial townships in our country and which are most adaptable

LOOSE BRICKS	TYPICAL TIME (MINT.) PER 1000 BRICKS	TYPICAL MAN (MINS) PER 1000 BRICKS	PACKED BRICKS	TYPICAL TIME (MINS.) PER 1000 BRICKS	TYPICAL MAN (MINS) PER 1000 BRICKS
1 MAN, 50'	65	65	1 MAN, 50'	20	20
1 MAN, 4'	50	50	1 MAN, 30'	20	20
FROM, 100', HOIST 3 FLOOR, 1 MAN, 30'	55	110	3 MIN, 100', HOIST 3 FLOOR, 1 MAN, 30'	25	75
4 MIN, 3RD FLOOR 1 MAN	15	75	1 MAN, 4 PACKAGE, 3RD FLOOR 1 MAN	12	25
5 MEN, 100', 4 MEN, 3RD FLOOR	15	135	6 MEN, 100', 3RD FLOOR, 1 MAN, 8 PACKAGE	7	50

COMPARISON BETWEEN LOOSE & PACKED BRICKS



Comparative Cost Graph of various systems of Material Transport



Kaiser Steel Corporation ore preparation plant at Mount Eagle