LIGHT & MEDIUM LOAD CONVEYOR TRANSPORTATION SYSTEMS

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SCOPE

This paper is intended to draw upon actual conveyor systems to illustrate equipment and techniques available for the horizontal transportation of light and medium loads. The discussion will include application guidelines and design criteria to aid in the system design, the selection of equipment, and the integration of the transportation subsystem into the User's total system.

Light and medium load systems are generally designed to convey cardboard cartons or totes with smooth, reasonably firm bottoms with sizes as noted below.

	Light	Medium
Length (inches)	6-30	6-48
Width (inches)	3-20	4-24
Height (inches)	2-20	2-24
Max. Weight (lbs./ft.)	20	150
Max. Speed (ft./min.)	100	250

Medium duty conveyors have been developed primarily for use in handling cardboard cartons of a size which could be easily handled by a person. Light duty conveyors were developed to handle empty cartons and small packages typically encountered in drug and cosmetic warehouses and in electronic manufacturing operations.

The speed limits are standards set to meet typical application and are not technology limits. With special components, speeds of 500 ft./min. are frequently used and speeds of 1000 ft./min. have been used in a few long distance transportation conveyors.

VIEWPOINT

A proper understanding of modern conveying system is best achieved by thinking in terms of material flow rather than material handling and by thinking of systems rather than hardware. We must also think in terms of control of both material and information flow.

A conveyor system is much like a modern automobile expressway network. Both are intended to receive discrete units of varying sizes from multiple inputs and to provide safe transport to a number of different destinations. Safe and efficient operation is achieved if the system can blend incoming traffic into mainline traffic, maintain proper spacing on the mainline, provide an accumulation buffer to take care of changes in mainline traffic flow rate, and allow exit without impeding mainline.

Men, machines and information are the three essential components of all conveying systems. Successful interfacing of these components is the major purpose of system design. Conveying systems are generally justified by an increase in productivity, therefore the primary system design goal must be to facilitate the efforts of men so that a given amount of human effort will yield a larger system output. Because the emphasis ought to be upon productivity improvement, we will have a better appreciation of conveying system design if we think in terms of "Mechanization", which implies facilitation of man's work rather than in terms of "Automation", which implies the removal of men.

SYSTEM

The majority of light and medium load conveying systems have been applied in warehousing so actual warehousing systems are the basis for discussion in this presentation. However, there is a growing use of light and medium conveying systems in "In-Process Manufacturing", and this application will soon become a major market for conveyor system suppliers.

A generalized block diagram of a warehouse in show in Figure 1. Vehicles and pallet handling conveyors are typically used for transport from receiving to storage. Light and medium duty load conveyors are typically applied for transport from picking to shipping docks. The flow diagram of such a transport system is shown in Figure 2.

Having defined the flow diagram, we can apply the following five basic material handling functions to achieve proper material flow and control –

Transport
Accumulate
Merge
Meter
Transfer

Considering general system requirements and people capabilities, we can determine the number picking aisles required and then apply material handling functions to obtain the refined flow diagram of Figure 3.

Next, we must give detail consideration to equipment and people capability, refine our control concept, interface with the building and interface with the management system. By repeated iteration we will arrive at a total system design such as our example system which has a general capability as follows:

7,200 Pick Locations
4,000 + S.K.U.'s
38,000 Cases per Shift
(70 Cases/Minute)

This specific system is typical of numerous applications in both food and general merchandise distribution and can be measured as follows:

…620 tons of Equipment
…230 tons of Support Steel
… 5 miles of Conveyor
…48,000 Rollers
…320 Electric Motors
…650 Horsepower
… 13 Programmable Controllers
… 38 Control Cabinets
… 52 miles of Wire

The two most important considerations of material flow are system throughput and conveyability –

…System Throughput

The system design must provide the capability of accepting input rates that vary widely due to picking imbalances between

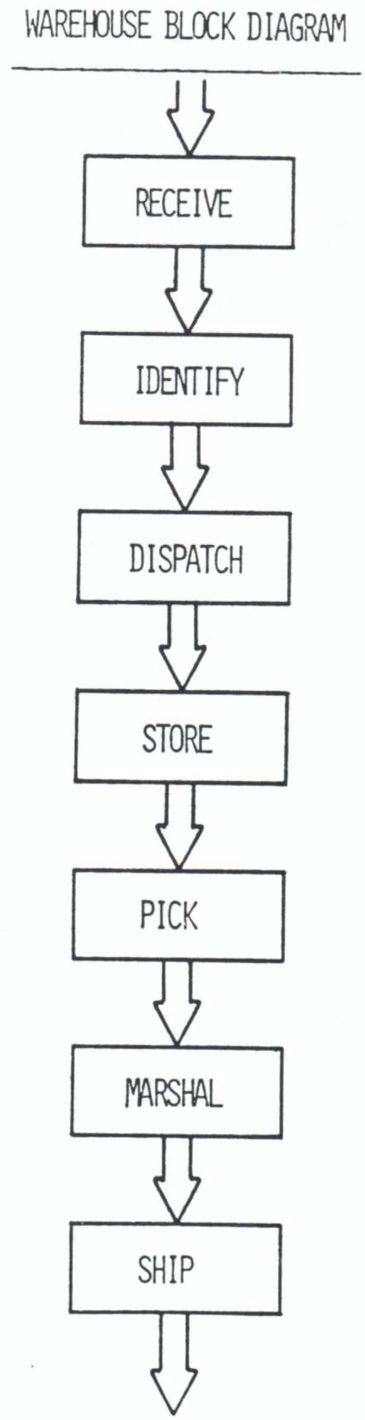

WAREHOUSE BLOCK DIAGRAM
RECEIVE
IDENTIFY
DISPATCH
STORE
PICK
MARSHAL
SHIP

Figure 1

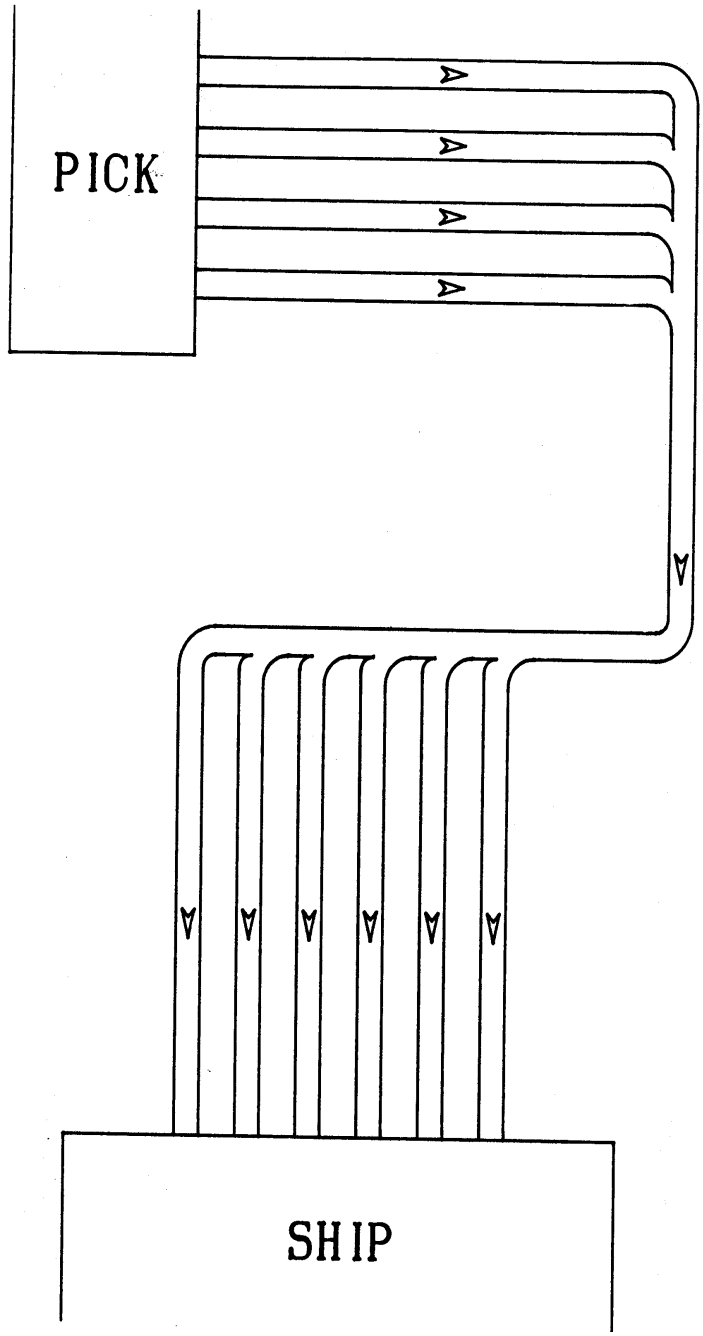


Figure 2

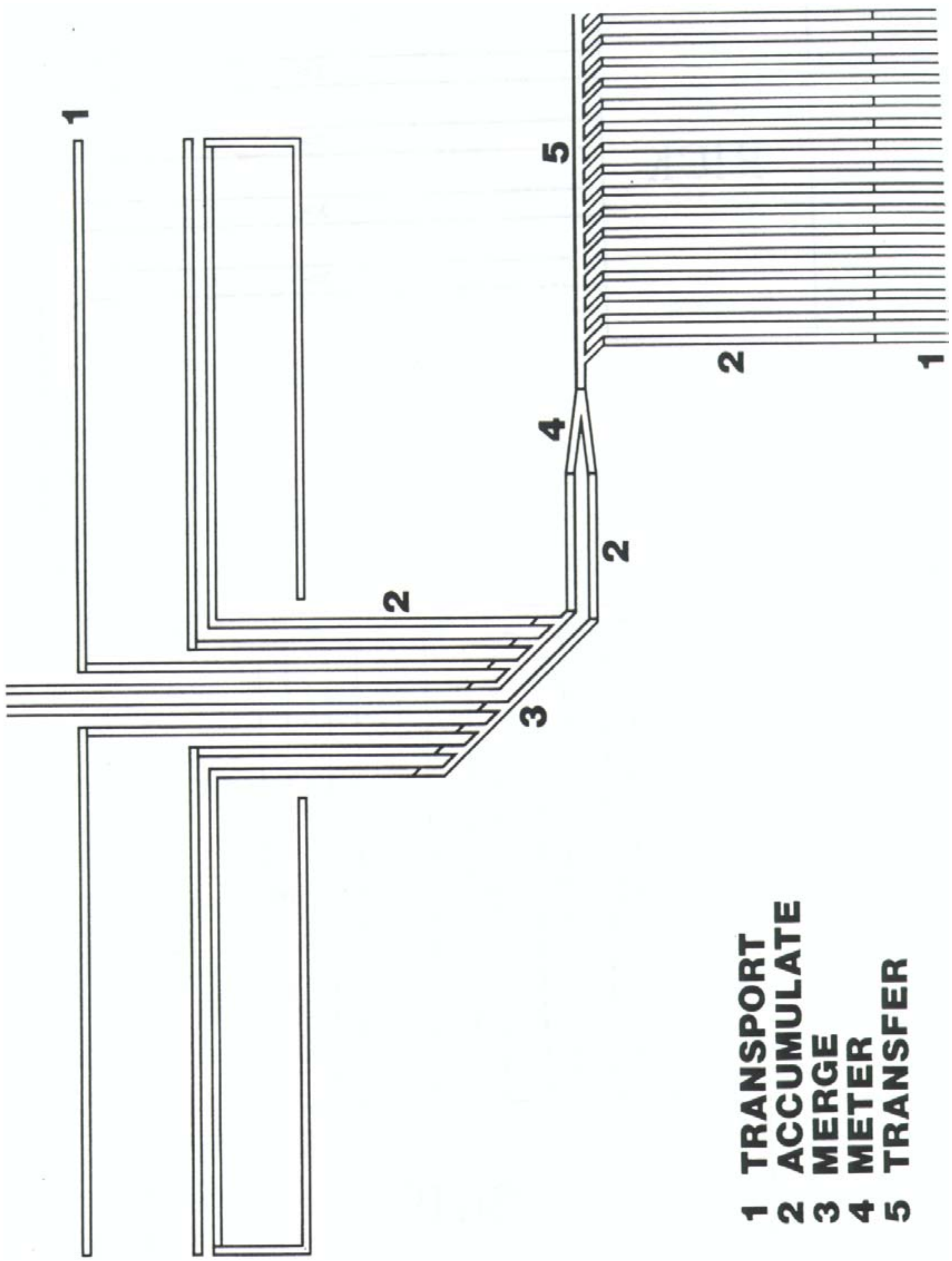


Figure 3

lines, availability of product, and picker capability; to achieve the required system throughput, the example system has a peak capacity of 105 cases per minute which is 150% of the required average throughput of 70 cases per minute.

…Conveyability

Product which cannot be conveyed requires additional cost for handling which depreciates the return on investment of the conveyor system; careful selection of handling equipment and control concept has resulted in systems that convey more than 90% of the items going through a general merchandise distribution center.

TRANSPORTATION

In our example system (reference Figure 3), a large amount of conveyor is required to transport product from the picker to the pre-merge accumulation and from the order accumulation bank to the truck loaders. Belt and rollers are the two basic conveying surfaces used in light and medium duty applications.

Belt on roller, slider bed and belt and wheel are the three principal design variations of belt conveyor (reference Figure 4); whereas, belt driven and rope driven are the two major design variations of roller conveyor (reference Figure 5).

Selection of the type of transportation conveyor is based primarily upon consideration of the following factors;

Conveyability – Capability of handling the range of product
Load Capacity
Transfer – Ease of transferring on or off
Energy Consumption
Noise
Maintainability
Cost

Figure 6 compare the various types of belt and roller conveyor using a rating scheme in which the lowest number indicates the most desirable type for the various application factors.

	TRANSPORTATION				
	Belt Conveyor			Live Roller	
Application Factor	Belt on Roller	Slider Bed	Belt & Wheel	Belt Driven	Rope Driven
Conveyability	1	1	3	2	2
Load Capacity	1	2	4	3	5
Transfer	4	2	3	1	1
Energy Consumption	3	5	1	4	2
Noise	2	1	3	5	4
Maintainability	3	2	1	5	4
Cost	4	3	1	5	2

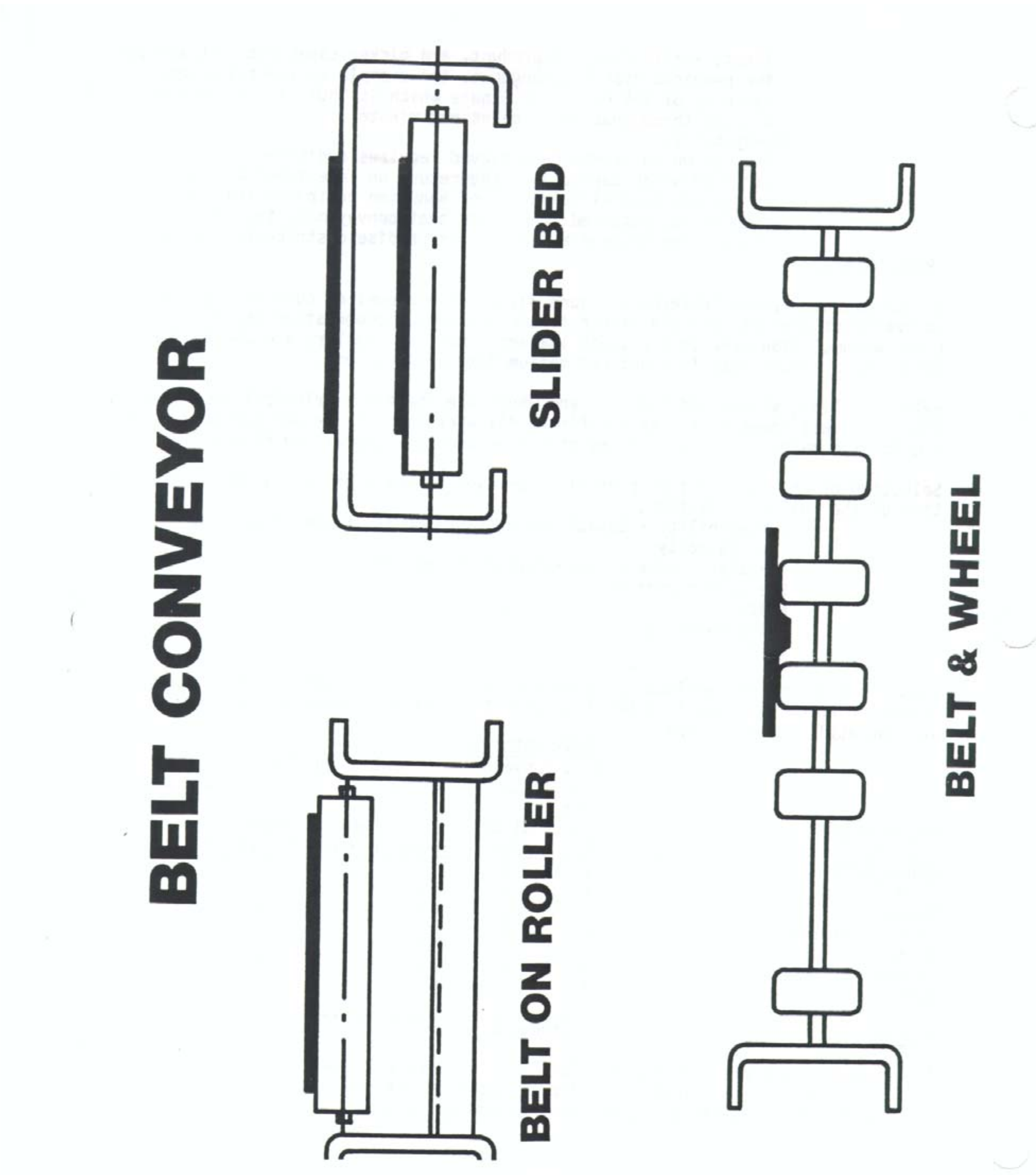


Figure 4

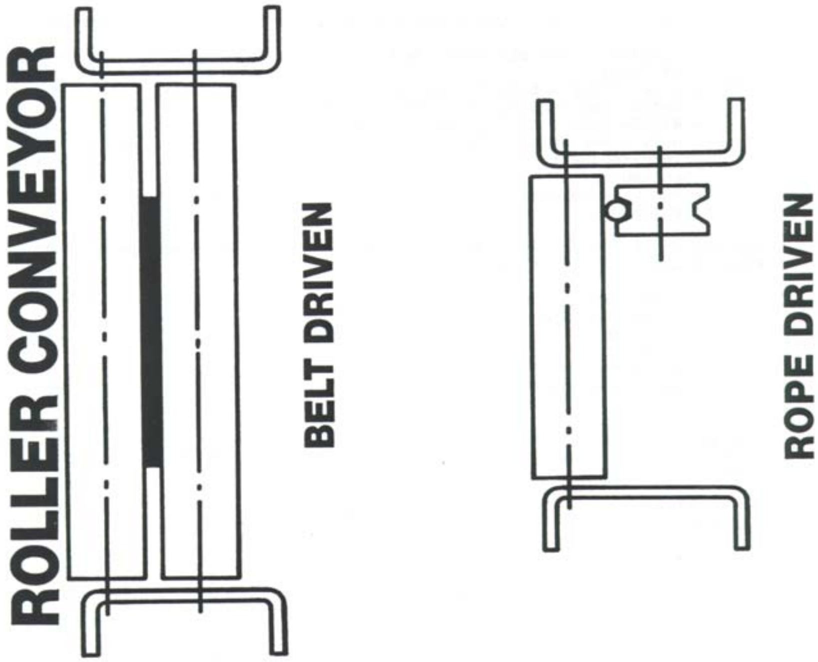


Figure 5

ACCUMULATION

Accumulation is a basic function which fills 4 different needs;

- Absorbs surges in material flow between operations
- Provides backlog ahead of machines and operations
- Provides accurate control of loads into transfers, merges, sizing stations, counters, etc.
- Reduces pressure so that loads may be removed from middle of a line

Our example system (reference Figure 3) uses accumulation to provide backlog ahead of the merge and the truck loading area and also to provide surge capacity between the merge and meter functions.

The principal forms of light and medium duty accumulation conveyors are –

- Gravity – most economical but unreliable discharge rate with wide range of loads
- Live Roller – belt driven live roller with low upward force on belt to obtain low forward drive and consequently, low accumulation pressure
- Ripple Belt – belt driven live roller with pads on belt that contact only a few drive rollers resulting in low forward drive

- Indexing Belt – belt conveyor indexed to receive load and stopped for accumulation
- A.P.C. – automatic pressure control which removes forward drive when a load is sensed

The choice of accumulation conveyor type is based upon experience and consideration of the following factors;

- Accumulation pressure
- Discharge rate
- Conveyability
- Noise
- Maintainability
- Energy Consumption
- Cost

Figure 7 rates the principal type of accumulators against these application factors using a rating scheme in which the smallest number is most desirable.

ACCUMULATION

Application Factor	Gravity	Live Roller	Ripple Belt	Indexing Belt	APC
Accumulation Pressure	3	5	4	1	2
Discharge Rate	5	1	4	2	3
Conveyability	5	2	4	1	3
Noise	1	3	2	5	4
Maintainability	1	3	2	5	4
Energy Consumption	1	4	3	5	2
Cost	1	2	3	5	4

FIGURE 7

MERGE

Our example system (reference Figure 3) has two 4 into 1 merges followed by a 2 into 1 merge. The choice of merge equipment is currently more of an art than a science due primarily to two factors;

- high speed merging is a relatively new requirement and there has not yet been time for standard designs to develop,

- the control scheme and mechanical design are so closely related that they cannot be easily disassociated into application modules.

Three general type of merges can be defined (reference Figure 8);

- Angular 2 into 1
- Parallel 2 into 1
- Multiple into 1

Primary application factors governing merge design are;

- Random or train output
- Conveyability
- Rates
- Reliability
- Cost

The 4 to 1 merges in our example system (reference Figure 3) are merging train inputs to achieve an average output of approximately 100 carton feet per minute.

Although the mainstream of merge development is aimed at simple mechanical design combined with microprocessor control to maintain spacing and load orientation, there have been successful applications of an "Unscrambler" (reference Figure 9). This device uses mechanical techniques of skewed rollers, progressively increasing speeds and high friction guardrail to merge multiple inputs without benefit of electronic control.

METER

The meter function receives a queue and outputs loads in an orientation, spacing, and speed suitable for the next downstream process such as carton sealing, banding, sortation, etc. In our example system (reference Figure 3), we have combined the meter function with a 2 to 1 merge and made the combination an integral part of the sortation subsystem as a cost reduction and space saving device.

Standards for meter equipment have not yet developed and so the mechanical equipment and control system are custom designed to fit the specific system need. The meter function of our example system (reference Figure 3) receives a queue of widely different size loads and produces an output of loads aligned on one side with equal space between the loads, all traveling at 300 feet per minute.

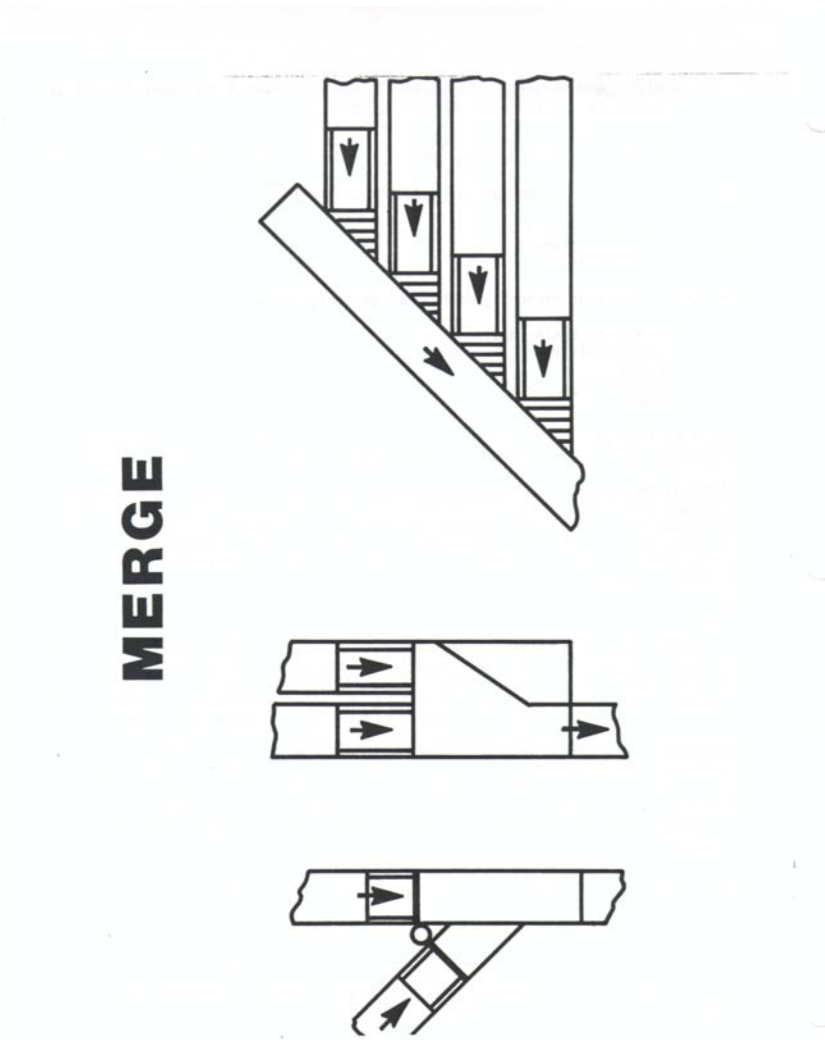
TRANSFER

There are two basic type of transfer (reference Figure 10);

- Translation
- Turning

Transfers are typically custom designed to meet the specific needs of the system and to interface with the control scheme chosen; however, the following types have found wide usage in light and medium duty conveyor systems;

- Push Off
- Tilt Off
- Combing Chain
- Deflector
- Pop-up Chain
- Skewed Wheel



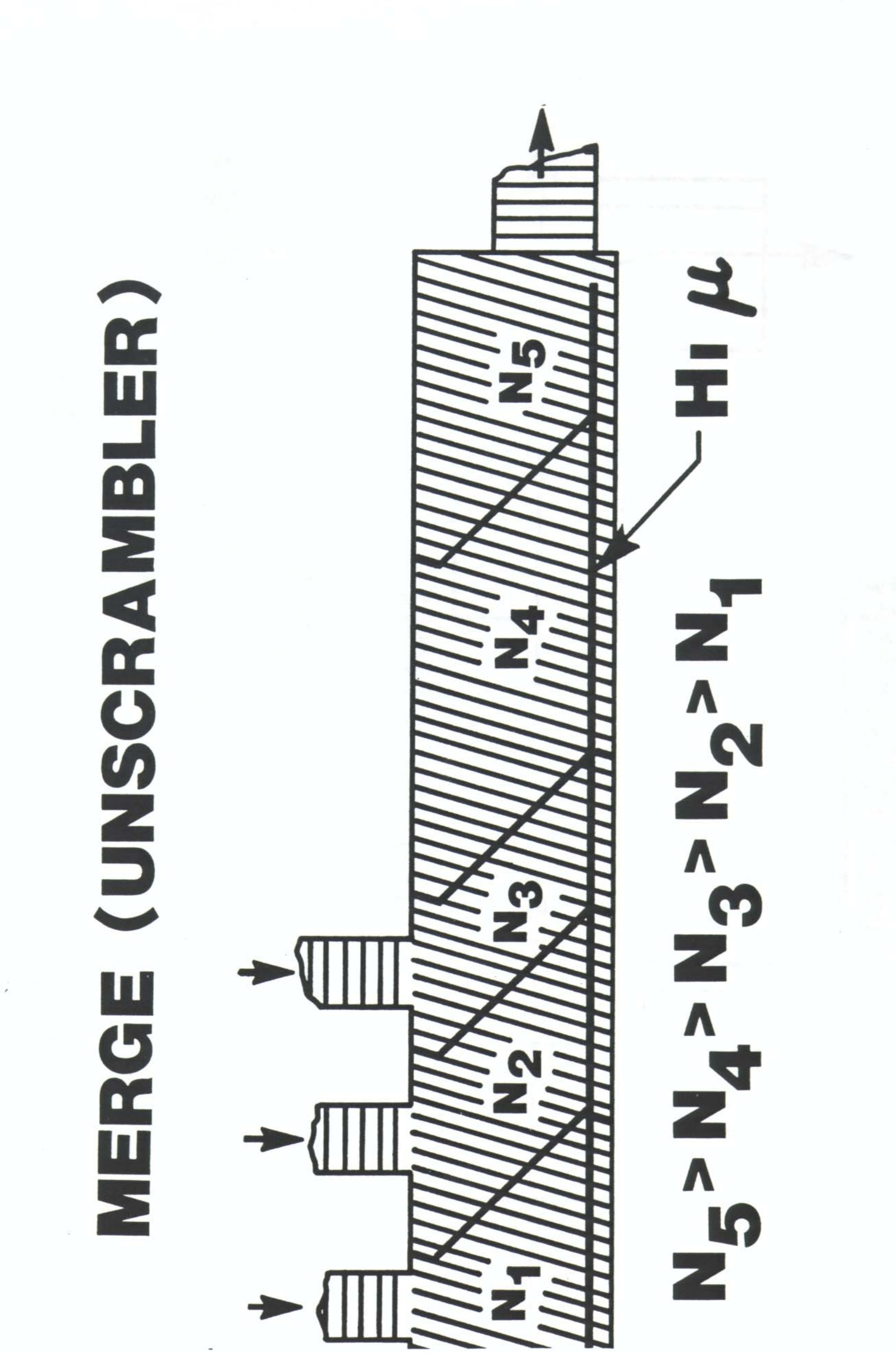


FIGURE 9

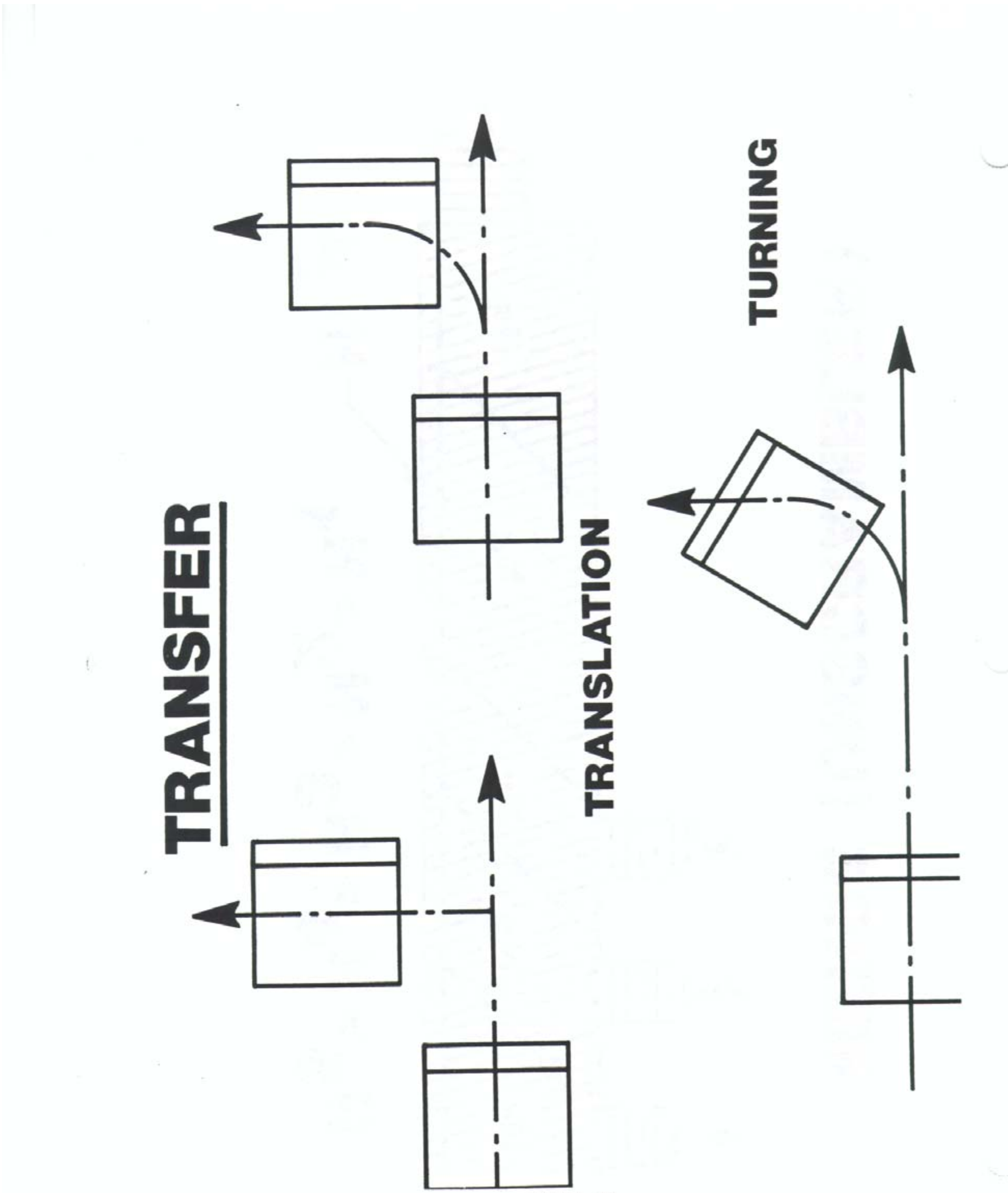


FIGURE 10

Figure 10 compares these types of transfers for the more important application factors. The rates specified in Figure 10 are based on loads with an average length of 17 inches.

	TRANSFER					
	Right Angle Pushoff	Tilt Off	Combing Chain	Deflector	Pop-up Chain	Skewed Wheel
Rate Loads/Minute	35	80	20	15	40	80
Conveyability	High	High	Low	High	Mod.	High
Maintainability	Mod.	Mod.	Mod.	High	Mod.	Mod.
Noise	Mod.	Mod.	High	Low	High	Low
Cost	Mod.	High	High	Low	Mod.	High

FIGURE 11

The transfers for our example system (reference Figure 3) are pop-up skewed wheel types which have a peak capacity of 120 loads per minute.

SUMMARY

I have told you that the successful interfacing of men, machine, and information is the major purpose of system design, but this presentation as well as most current literature is generally limited to machines and information. The lack of attention to the capabilities of men and of the relationship of me to the physical system reveals a great weakness in our industry and our profession. To achieve our productivity goals, we must spend more money on man/machine research and then turn this research into practical application in our future system designs.

I have defined five basic functions and described how these functions have been combined into a conveyor system. I have suggested application factors to be considered in evaluating equipment to perform these functions and have compared principal designs against these factors. I hope that I have succeeded in giving you a beginning point adequate to define the current state of the art and to allow you to evaluate system concepts.

I have not discussed the need to reduce audio noise or to ensure safety in conveying systems. These are major environmental concerns facing our industry and good progress is being made. But I caution you that Society has expectations in these areas that can be met only by large increases in system cost.

I have talked of throughput rates which are current state of the art and it is obvious that greater productivity can be achieved if these rates were to be increased. I believe that we are close to the limit of the throughput and speed we can achieve with our current conveyor design and manufacturing concepts.

To break this barrier, we will have to develop designs and manufacturing skills similar to machine tool practices which will, of course, move the cost of the equipment into a substantially higher category.

The current state of the art of conveying and control equipment has resulted in many fine conveyor systems which have raised worker productivity and yielded excellent R.O.I. But, many of these systems have been based upon centralization of distribution into one large facility with much of he savings coming from economy of scale. As the price of oil increases our cost of transport and as our economy growth rate flattens out, we must look to future productivity increases to come not from economies of scale but rather to come from economies of skills, and so I close with this thought –

> Productivity improvement comes from improvement of the management system and from mechanization of material handling activities.
>
> Often times, the R.O.I. of improving the management systems is greater than R.O.I. of mechanizing the material handling activities.