CRANE HANDBOOK

Design Data and Engineering Information used in the manufacture and application of Cranes.

Compiled by

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WHITING CORPORATION

Harvey, Illinois

Third Edition

WHITING

FOREWORD TO THIRD EDITION

In 1930, when the first edition of "Crane Engineering" was printed, crane design was in a transition period. A few years earlier, during the high production years of 1925 through 1929, efficiency and maintenance men, seeking to lower operating costs, made a demand for high efficiency, low maintenance and greater safety in electric cranes.

The Whiting Corporation met this demand with the introduction of the roller bearing crane and the development of a line of standardized parts. Since 1928, when the first crane of this type was placed in service, the use of standard parts has been extended to cover all capacities of cranes under all service conditions. We are continually striving to improve our cranes, and to carry out the demands of higher efficiency, lower maintenance and greater safety.

The second edition entitled "Crane Handbook" was completely revised to cover practices in crane engineering as accepted prior to 1955. No space was given to designs then considered obsolete. Consideration was given to crane service in an effort to make the users of cranes aware of the various classes of service and of the requirements for good performance in each class.

This third edition is revised to include the many advancements that have been made since 1955, especially those made in control and safety features of cranes. Standard clearances have been revised and maximum wheel loads modified to suit present day design.

We wish to thank the users of previous editions for the enthusiasm with which they received those editions and for their reference to them for crane engineering information. Continued progress in design and application of cranes suggests this new edition be made to follow up the original "Crane Engineering" and the subsequent "Crane Handbook."

WHITING CORPORATION
Harvey, Illinois

APRIL, 1967

INTRODUCTION

With the development of "automation", the automatic factory, the material handling problem must be given major consideration. The production schedule becomes dependent upon the material handling system. A properly designed crane is an important unit in material handling and must be depended upon to bring about increased production, lower shop costs, and better working conditions.

The Whiting Corporation with over eighty successful years of manufacturing and about sixty-nine years experience in building overhead cranes and other material handling equipment, has met a multitude of problems in filling the needs of our many customers and is in a position to assist in solving your material handling problem.

The Whiting Corporation wishes that this revised volume of the Crane Handbook will not be considered an advertisement, but an honest effort to give the present and future users of cranes the fundamentals of crane design. This book gives two types of information covering, (1) general crane design, various types of cranes with related equipment and (2) specifications, clearances, speeds and specific details of equipment as manufactured by the Whiting Corporation based on many years of engineering skill and sound experience.

This book will enable engineers and executives to familiarize themselves with crane engineering and to specify modern, correctly designed equipment produced from proper materials and entirely suitable for the type of service required. A saving to the buyer is effected by the use of standard parts designed and manufactured by the crane builder, rather than special units prescribed by the crane buyer. The responsibility of performance should be on the crane builder and the Whiting Corporation is ready to assume that responsibility when asked to furnish equipment to do a specified job.

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SECTION I – HISTORY OF CRANE DESIGN

Traveling cranes of the hand operated type were in use in the 1880's. About this time complicated designs of powered motion were offered by English and American builders, involving a driving shaft along the runway and multiple clutches for transferring the power of the driving shaft to the hoist, trolley or bridge motions.

The first three-motor eletric crane was placed in operation in 1890. J. H. Whiting, founder of the Whiting Corporation, built the first three-motor Whiting crane in 1898. Early speeds were slow and capacities limited, with 40 tons a maximum capacity.

Crane design has changed about every 20 years. 1880 saw the handpowered crane; 1900 the electrically driven crane with a motor for each motion; by 1920 definite standards had been established for cranes in general and for various types of service; 1940 brought the enclosed gear cases, roller bearings and standardized designs; and 1960 produced the changes in crane control which resulted in smoother operation, safer handling of loads, remote operation and new safety features for protection of equipment and personnel.

From the slow speeds and limited capacities of the early cranes, we now find hoisting speeds of over 200 f.p.m., bridge speeds as high as 1000 f.p.m. and hoisting units to handle 500 tons with a single hook.

Improvements in crane designs have come from both the users of cranes and the crane builders. Outstanding contributions have been made by the engineers of the steel industry, who at an early date stressed higher speeds, heavier capacity, ruggedness, greater safety, easier maintenance and standardization of parts. In 1927, with industry demanding greater efficiency, quieter operation, complete enclosure of all gears and an oil-tight anti-friction bearing crane, the Whiting Corporation introduced its Tiger Crane with all these features. Since that time, other manufacturers have followed our lead in giving to industry better equipment for use in the material-handling field.

The present trend toward precision handling of materials, especially in the machine-tool industry, has created a demand for a simple crane control that will permit precise movements of the crane hook in all directions. The crane and electrical manufacturers have developed and are now perfecting systems of control that result in the operator's precision control of all crane motions, as well as reduced maintenance costs due to simplified equipment. Much progress has been made toward automatic overhead material handling for warehouses and production lines in machine, assembly, packaging and shipping operations. "Wireless" remote control is another feature of the continued research and development program of the crane builders and related equipment manufacturers.

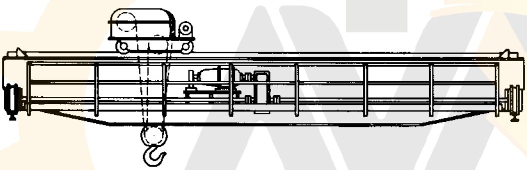
SECTION II – TYPES OF CRANES

This section shows the many types of cranes which are in use today to fulfill the demands of material handling problems. It is by no means complete, but does cover those cranes made by the Whiting Corporation in the past 69 years, many of the early cranes still being in service.

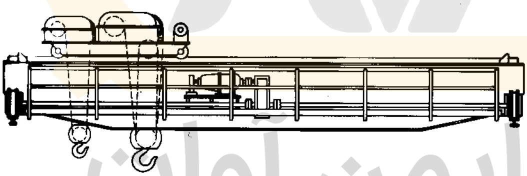
A line drawing, title and brief description of use for each type of crane is given.

OVERHEAD TRAVELING CRANES

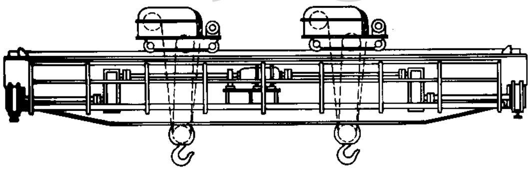
Each of these cranes can be made to suit the classification of cranes as described in Section IV in capacities from 3 to 500 tons. All may be arranged for either cab, floor, or remote control or any combination of the three types. Either type of bridge drive may be furnished depending on span of crane.



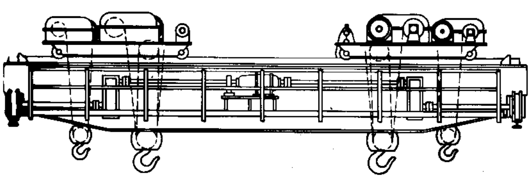
3-MOTOR, SINGLE TROLLEY
General Service



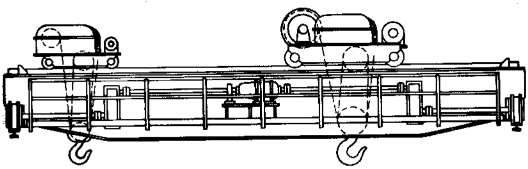
4-MOTOR, SINGLE TROLLEY
Slow speed main hook for heavy loads; fast speed auxiliary hook for light loads.



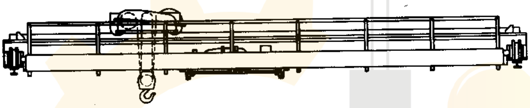
5-MOTOR, DOUBLE TROLLEY
Two equal hoists for easy and safe handling of long loads at any desired centers.



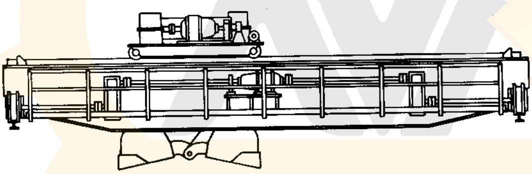
7-MOTOR, DOUBLE TROLLEY
Two main hooks for heavy loads at slow speeds and near approach for fast auxiliary hooks at both sides of building.



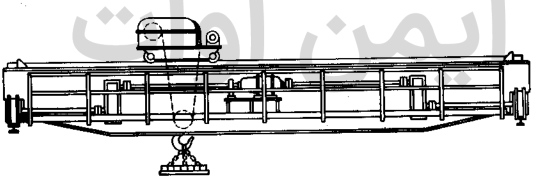
5-MOTOR, DOUBLE TROLLEY
One heavy and one light capacity trolley for heavy single load; light, long loads. More flexible than 4-motor single trolley.



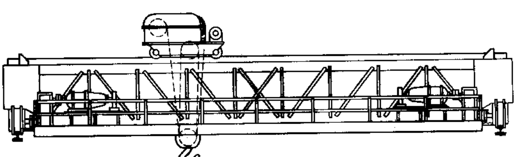
3-MOTOR HI-LO SINGLE TROLLEY
Special low-headroom type having least distance from underside of roof truss to palm of hook. Class B and C up to 10 tons only.



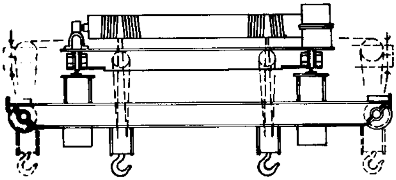
4-MOTOR, BUCKET TROLLEY
Handling coal, ashes, cement, fertilizer and similar materials.



3-MOTOR, MAGNET TROLLEY
Rugged design for severe service in foundry make-up, scrap, and steel storage yards.



LATTICED GIRDER,
For spans above 125′-0″ the latticed girder is recommended for any of the foregoing types of overhead cranes, especially for outdoor service.

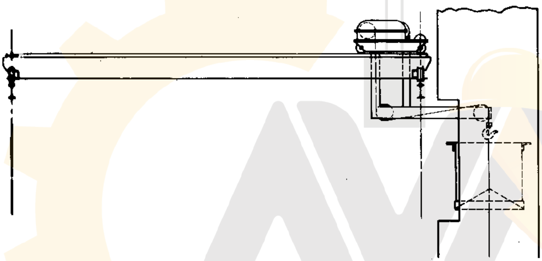


3 OR 4-MOTOR DOUBLE-HOOK TROLLEY

Two hooks on same trolley at right angles to bridge girders for special beams and grapples. Hooks may be between girders as shown or outside of girders as indicated by broken lines.

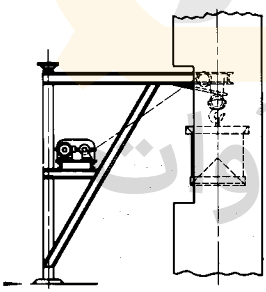
CUPOLA CHARGING CRANES

These cranes usually are rated Class D or E service and made in capacities from 2 to 7½ tons.



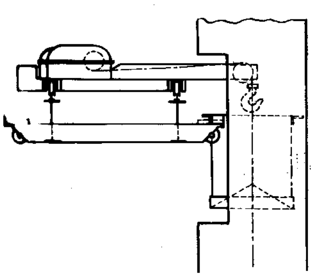
UNDERSLUNG CHARGER

Charging boom extends into cupola from end of trolley under runway beam. Cupolas in line parallel with runway.



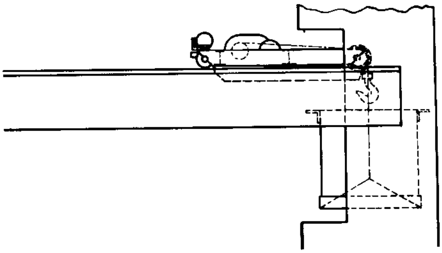
JIB CHARGER

Charging boom swings through fixed radius on which one or two cupolas and the pickup point are located.

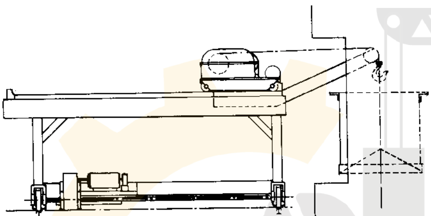


OVERHEAD CHARGER

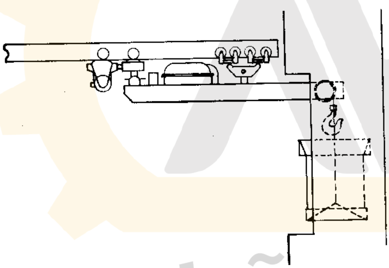
Charging boom extends into cupola from side of trolley. Cupolas in line at right angles to runway.



HORSESHOE CHARGER
Charging boom extends into cupola from trolley running on a fixed runway straddling each cupola.



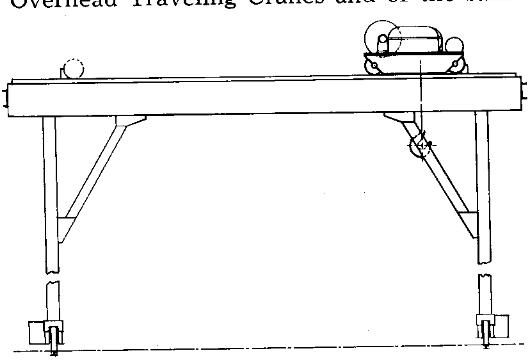
GANTRY CHARGER
Charging boom extends into cupola from end of trolley. Cupolas in line parallel to gantry tracks which are on charging floor.



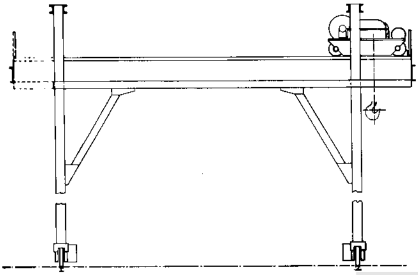
MONORAIL CHARGER
Charging boom extends into cupola from end of trolley running on monorail track in line with center of each cupola.

GANTRY CRANES

These cranes can be made to suit any class as described in Section IV. The trolley arrangement may duplicate any one shown under Overhead Traveling Cranes and of the same capacities.

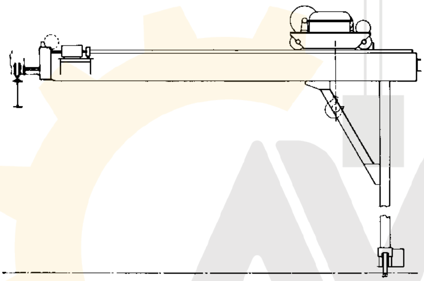


DECK-LEG GANTRY
Both tracks at ground level. Trolley travels between legs only.



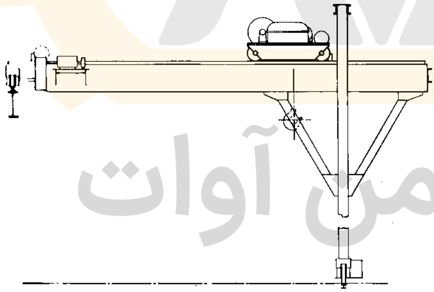
THROUGH-LEG GANTRY

Both tracks at ground level. Trolley travels through legs on overhangs which may be at one end or both ends of bridge.



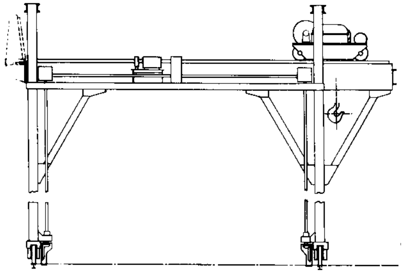
SINGLE-LEG GANTRY, DECK-LEG

One end of bridge on high runway. Trolley travels between upper runway truck and gantry leg only.



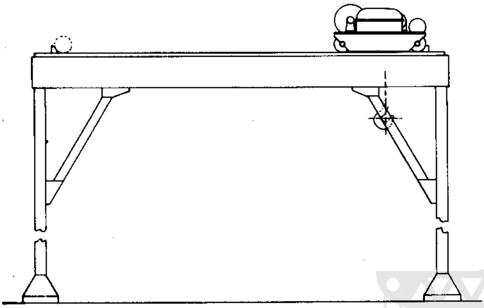
SINGLE-LEG GANTRY, THROUGH-LEG

One end of bridge on high runway. Trolley travels from upper runway truck through leg on overhang.



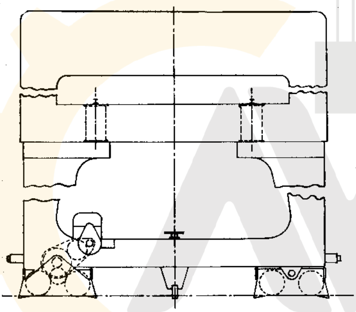
LUFFING-BOOM GANTRY

This may be either single or double leg with luffing-boom overhang which is raised to clear obstructions outside of gantry leg during travel motion.



STATIONARY GANTRY

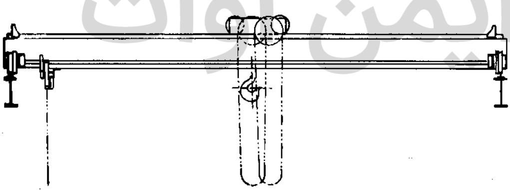
Two or three motor trolley running on a fixed bridge. Used for transferring loads on parallel tracks, roadways or platforms.



GATE-HANDLING GANTRY

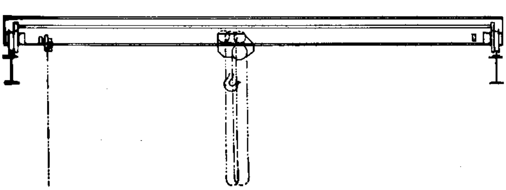
Special crane for handling gates, racks and hoists in water-power plants located at large river dams.

HAND POWER OVERHEAD CRANES



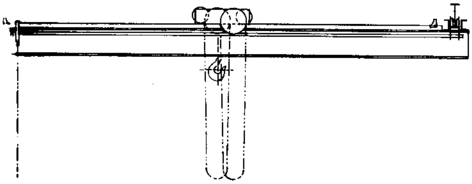
DOUBLE GIRDER TOP-RUNNING BRIDGE

with low headroom top-running trolley. May also be electrified. Capacities to 40 tons.



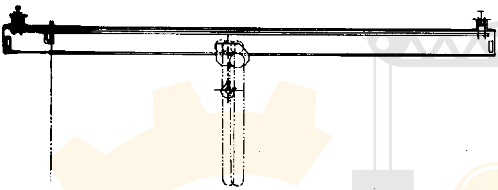
SINGLE GIRDER TOP-RUNNING BRIDGE

with under-hung trolley hoist of the chain or cable type. Capacities to 10 tons.



DOUBLE GIRDER UNDER-HUNG BRIDGE

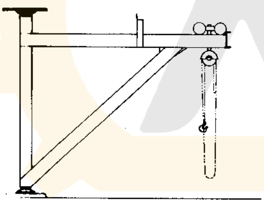
With top-running low headroom trolley. Capacities to 20 ton.



SINGLE GIRDER UNDER-HUNG BRIDGE

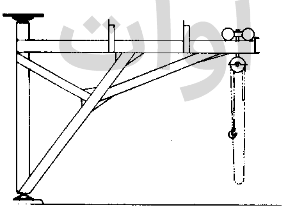
with under-hung trolley hoist of the chain or cable type. Capacities to 5 tons.

HAND POWER JIB CRANES



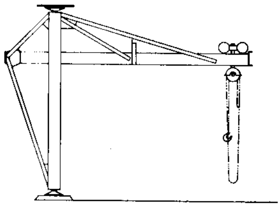
SINGLE UNDERBRACED, TYPE A

with top-running trolley, double-channel boom; trolley travel and load size limited by bracing. General purpose use in localized area.



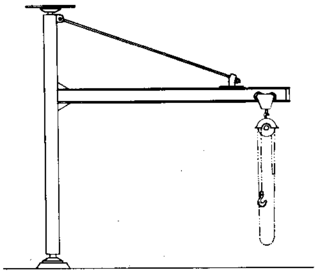
TRIPLE UNDERBRACED TYPE B

with top-running trolley. Same as above except for larger effective radius and heavier capacity.



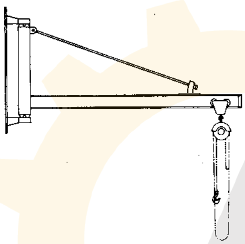
TRIPLE TOP-BRACED TYPE C

with top-running trolley provides maximum unobstructed hook coverage for required effective radius. Used to 10 ton capacity in localized area.



SINGLE TOP-BRACED
TYPE D

Single beam boom with under-running trolley hoist. Hoist may be of the chain or cable type operated by electric or hand power. Used to 2 tons capacity to serve localized area.



WALL BRACKET TOP-BRACED
TYPE E

Single beam boom with same hoist arrangement as above. Used to 2 tons capacity to serve localized area.

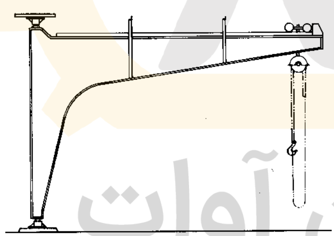
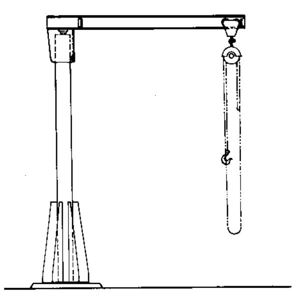


PLATE MAST & BOOM
TYPE F

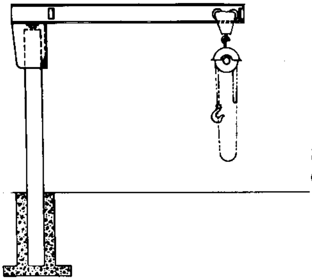
Double member boom with top-running trolley arranged for chain or cable hoist attachment. Capacity to 15 tons for heavy shop and assembly floors.

HAND POWER PILLAR CRANES



FLOOR-MOUNTED

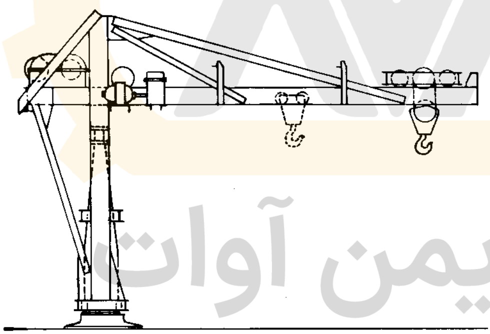
Single beam boom with under-running hoist. Hoist may be of the chain or cable type operated by electric or hand power. Used to serve machine shops and assembly floors.



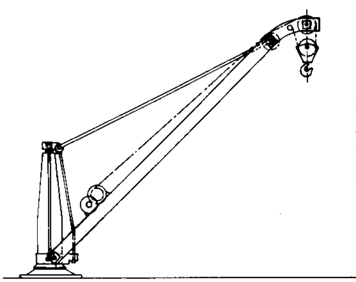
GROUND MOUNTED
Same construction and use as previous crane, except for base mounting.

ELECTRIC PILLAR CRANES

For all classes of service; used extensively in the railroad maintenance field. Capacities to 10 tons and radii up to 25′-0″. Arranged for full 360° rotation.

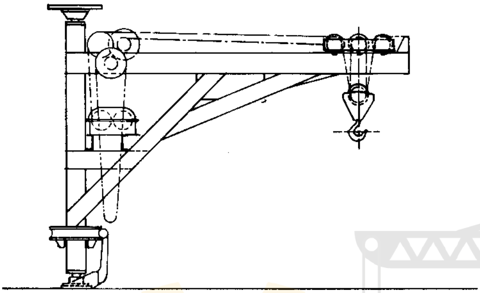


TOP-BRACED
with flying trolley as shown in full lines or with under-running trolley as shown in dotted lines. Mounting hoist unit on boom at mast permits light-weight trolley for handling the maximum possible load. 15 tons capacity at 20 ft. radius in forge and heavy machine shops.



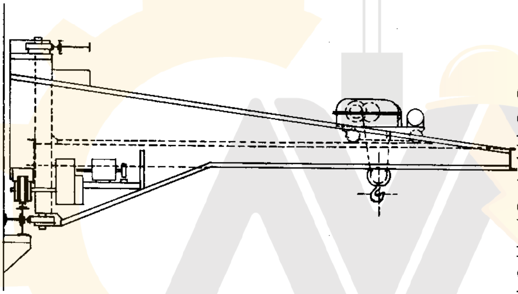
FIXED RADIUS
This type used extensively as hand-power, electric or air-operated on loading docks at freight stations up to 12 tons capacity.

SPECIAL ELECTRIC CRANES



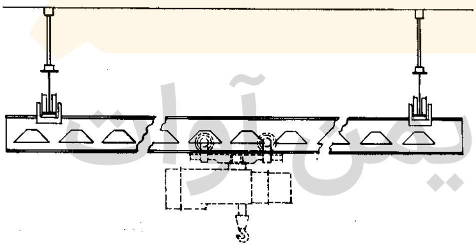
SPOUT HOIST JIB

Steel Mill Class — This crane is usually set between two open hearth furnaces to handle the pouring trough at the hot-metal ladle.



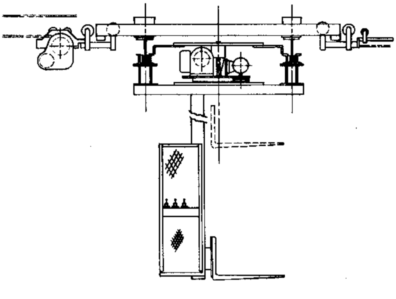
3 OR 4-MOTOR WALL BRACKET CRANE

Class C & D — This crane covers the area near the building columns without obstruction in the working area or the adjacent area. Used to 10 tons capacity in foundry molding and cleaning bays and structural fabrication shops.



TRAMBEAM CRANE

This is a special underhung crane in many different forms as described in Section XII.



UNDERSLUNG STACKER

Bridge may be top-running or underhung with underhung trolley on which is mounted a vertical fork or platform for handling the load. Three ton capacity.

SECTION III – CRANE TERMINOLOGY

In this section definitions are given for the terms which are peculiar to crane engineering and when used in conjunction with Section II should make the following sections of this handbook readily understandable.

AUXILIARY HOIST—A supplemental hoisting unit consisting of motor, coupling, brakes, gearing, drum, ropes and block to handle lighter loads at faster speeds than provided for the main hoist.

BLOCK—See load block.

BRAKE—A device retarding or stopping motion by friction or power means.

BRIDGE—That part of a crane consisting of girders, walk, railing, shafting, drive and trucks which carries the trolley or trolleys and travels in a direction parallel to the runway rails.

BRIDGE COLLECTOR—Contacting device mounted on bridge for collecting current from conductor system mounted on crane runway.

BRIDGE CONDUCTOR—Wires, angles, bars, tees, or special sections mounted on the bridge to transmit current to trolley collectors.

BRIDGE CROSS-SHAFT—Shaft extending across the bridge to transmit torque from motor to bridge drive wheels.

BRIDGE DRIVE—Motor, couplings, brake and gear case, or gear cases to propel bridge.

BRIDGE TRAVEL—Horizontal travel of crane parallel with runway rails.

BRIDGE TRUCK—Assembly consisting of wheels, bearings, axles and structural frame supporting bridge girders.

BUMPER—An energy-absorbing device for reducing impact when a moving crane or trolley reaches the end of its permitted travel.

CAPACITY—Tons of 2000 pounds each.

CONTROL BRAKING MEANS—A method of controlling crane motor speed when in an overhauling condition.

CONTROLLER—A device for regulating in a pre-determined way the power delivered to the motor or other equipment.

COUNTERTORQUE BRAKING—Method of control in which the power to the motor is reversed to develop torque in the opposite direction.

DRIVE GIRDER—Front girder on which is mounted the bridge drive, cross shaft, walk, railing and usually the operator's cab.

DRUM—The cylindrical member around which the ropes are wound for raising or lowering the load.

DYNAMIC BRAKING—Method of control in which the motor is so connected that when it is overhauled, it acts to provide retarding force.

EQUALIZER—A device which compensates for unequal length or stretch of a hoist rope.

FACTOR OF SAFETY—Ultimate strength of material divided by maximum stress in each unit part.

FAIL-SAFE—A condition under which a control feature stops any motion in which a malfunction occurs.

FPM—Feet per minute.

HOIST MOTION—That motion of a crane which raises and lowers a load.

HOLDING BRAKE—A brake that automatically prevents motion when power is off.

HOOK APPROACH—The minimum horizontal distance between the center of the runway rail and the hook.

IDLER GIRDER—Back girder with no drive machinery.

KNEE BRACE—The diagonal structural member that joins the building column and roof truss.

LEFT HAND END—Reference to parts on the viewer's left of centerline of span when facing the drive girder of the crane.

LIFT—Maximum safe vertical distance thru which the hook can travel.

LOAD BLOCK—The assembly of hook, swivel, bearing, sheaves, pins and frame suspended by the hoisting ropes.

MAIN HOIST—A hoisting unit consisting of motor, coupling, brakes, gearing, drum, ropes and block to handle maximum rated loads.

OPERATOR'S CAB—The operator's compartment from which movements of the crane are controlled.

OVERHEAD CLEARANCE—Distance from top of crane to low point of roof truss or overhead lights, ducts, wiring, etc.

RAIL TO ROOF TRUSS—Distance from top of runway rail to low point of roof truss or overhead obstruction.

RATED LOAD—The maximum load for which a crane or individual hoist is designed and built by the manufacturer and shown on the equipment nameplate.

REGENERATIVE BRAKING—Form of dynamic braking in which the electrical energy generated is fed back into the power system.

RPM—Revolutions per minute.

RIGHT HAND END—Reference to parts on the viewer's right of centerline of span when facing the drive girder of the crane.

RUNNING SHEAVE—A sheave which rotates as the load block is raised or lowered.

RUNWAY—The assembly of rails, girders, brackets and framework on which the crane operates.

SIDE CLEARANCE—Distance from extreme of crane to side obstruction, face of column, wall, downspouts, conduit, etc.

SPAN—The horizontal distance center to center of runway rails.

STOP—A device to limit the travel of a trolley or crane bridge.

TROLLEY—The unit consisting of frame, trucks, trolley drive, and hoisting mechanism moving on the bridge rails in a direction at right angles to the crane runway.

TROLLEY COLLECTORS—Contacting device mounted on trolley for collecting current from bridge conductors.

TROLLEY DRIVE—Motor, couplings and gear case to propel trolley.

TROLLEY DRIVE SHAFT—Shaft extending across the trolley to transmit torque from motor to trolley drive wheels.

TROLLEY GIRTS—Structural members which are supported on the trolley trucks and contain the upper sheave assemblies.

TROLLEY TRAVEL—Horizontal travel of trolley at right angles to runway rails.

TROLLEY TRUCK—Assembly consisting of wheels, bearings, axles and structural supporting hoist mechanism and load girts.

WHEEL BASE—Distance between centers of outermost wheels for bridge and trolley trucks.

WHEEL LOAD—The load on any wheel with the trolley and lifted load (rated load) positioned on the bridge to give maximum loading condition.

SECTION IV
CLASSIFICATION OF OVERHEAD TRAVELING CRANES

The purchase of a crane represents a major expenditure to all plants; as such it should be selected with utmost deliberation. Being essentially an engineering proposition, the wise buyer will take advantage of the service offered by reputable crane builders in deciding on the type of crane to do the required job at the least initial cost and the lowest operating and maintenance expense.

The first consideration must be to obtain a crane that will adequately perform the work which is to be done. The required performance determines the service classification of the crane to be purchased. The classification influences the design of all of the components of a crane from the hook to the operator's cab, including motors, brakes, gear drives, shafting, wheels, bearings, structural, limit switches, control and collectors.

From the above it is evident that if a slow speed crane can do the job, it will cost much less than a crane with high speeds and heavy duty construction. For this reason, service classifications have been established.

As this handbook will primarily cover overhead traveling cranes, they are identified according to service in six classes; the service requirements of each motion of the crane — bridge, trolley, main hoist, auxiliary hoist — may not fall into the same service class and must be reconciled to give the most efficient and economical selection.

Class A. STANDBY SERVICE — Cranes placing machinery during erection, and thereafter used only during the servicing of the machinery, come under the classification of standby service. After the erection work is completed, such a crane may be idle for long periods of time and may never again lift the rated load. This service permits 2 to 5 capacity lifts per hour. The maximum load of the crane is usually known, so that specifications can be drawn up accordingly. All motions should have variable-speed control to assure very slow speed, permitting accurate handling of the load. Slow speeds also allow the use of smaller motors, electrical equipment, and mechanical parts which reduce the investment in equipment that is seldom used. Applications include power house, pump room, motor room, transformer repair, etc.

Class B. LIGHT SERVICE — This service covers floor-operated cranes that are not in constant use and have no specific person employed to operate them. They are capable of 5 to 10 capacity lifts per hour. A crane in this class may be idle for extended periods and at times may be in fairly constant operation. Applications include repair shops, light assembly work, service buildings, and light warehouse service. The speeds should be slow. Accurate spotting of loads is not required.

Class C. MODERATE SERVICE — This service covers cab, floor and remotely operated cranes such as used in machine shops, assembly floors, foundries, fabricating shops, paper mill machine rooms, etc. where service requirements are medium. They are capable of 5 to 15 capacity lifts per hour. Speeds are medium. Specifications should permit design life and construction based on intermittent usage in the handling of average loads of 50% or less of rated load.

Class D. HEAVY DUTY SERVICE — This service covers cab-operated cranes such as used in heavy machine shops, foundries, fabricating plants, stamping plants, steel warehouses, lumber plants, etc. and for standard duty bucket and magnet operations where heavy duty production is required with no specific cycle of operation. Crane service is an important part of the production process and requires dependable operation with from 10 to 20 capacity lifts per hour. Speeds are medium to fast and depend on the capacity and general duties of the crane. Specifications should include a minimum safety factor of 5 in all parts, with roller bearings, totally enclosed gearing, 30′ rated motors, and variable speed control.

Class E. SEVERE DUTY CYCLE SERVICE — (Continuous material handling.) Cranes in this class must be high speed, rugged, with long-life wearing parts and with motors and brakes selected for the duty cycle involved and capable of making 20 to 40 lifts per hour. Applications include magnet, bucket, magnet-bucket combination, scrap yards, and stock yards handling coal, cement, stone, lumber, sand and fertilizers. Minimum down-time is a prime consideration. The cycle of operation required for each motion should be clearly defined.

Class F. STEEL MILL (AISE SPEC.) — Cranes in this class are covered by the current issue of the Association of Iron and Steel Engineers Specifications for Electric Overhead Traveling Cranes for Steel Mill Service which emphasize safety features, ruggedness, high factors of safety, long life of wearing parts, accessibility, oil tightness and usually fast speeds. Electrical equipment is generally of the mill type. Mill engineers justify the high standards they set by pointing out that when a mill is in continuous operation a shut-down due to a crane failure would be far more costly than the additional investment required to get the type of crane they consider proper. 40 to 80 capacity lifts per hour is considered normal for cranes in this class.

The foregoing are broad classifications to assist the crane user in determining the general classification for the crane he should specify. A more detailed statement about speeds, clearances, specifications, and engineering for each classification is given in sections which follow.

SECTION V — SELECTION OF OPERATING SPEEDS

After the crane to be purchased has been properly classified, the next important step is to select the proper speeds for that classification and the cycle of operation in which the crane will be used.

Speeds for each motion are prime factors in determining the original and operating costs of a crane; therefore, if crane speeds are chosen that are greater than necessary for the required crane use, the cost of the crane and subsequent cost of power would be higher due to the larger motors, controls, gear drives, etc. On the other hand, if crane speeds are inadequate when the crane is used in a production cycle, it is possible that the crane could cause economic loss by being a bottleneck in the cycle.

When a duty cycle must be met, it is necessary to analyze the speed requirements in detail. Typical problems are analyzed on pages 24 and 25.

The speeds shown in Table 1 are the recommendations of many years of experience in the overhead material handling field. These will result in the most economical original crane cost because of the use of manufacturer's standard components which are made in quantities to reduce overall cost and provide a quick and reliable source of repair parts.

Table 1. RECOMMENDED CRANE SPEEDS. Feet Per Minute

Capacity In Tons	HOIST			TROLLEY TRAVEL			BRIDGE TRAVEL		
	Slow	Medium	Fast	Slow	Medium	Fast	Slow	Medium	Fast
5	25	40	60	100	150	200	150	300	400
7½	30	55	90	100	150	200	150	300	400
10	30	55	90	100	150	200	150	300	400
15	15	27	45	100	150	200	150	300	400
20	15	28	36	100	150	200	150	300	400
25	10	18	24	100	150	200	150	300	400
30	10	18	24	100	150	200	150	300	400
40	6	10	17	80	150	200	100	150	200
50	6	10	17	80	150	200	100	150	200
60	4	8	14	80	110	150	75	100	200
75	4	7	11	50	100	150	50	100	150
100	4	7	9	50	100	125	50	100	150
125	3	5	7	40	75	100	50	100	150
150	3	5	6	30	50	100	50	75	100
175	3	4	5	30	50	75	50	75	100
200	3	4	5.5	25	35	50	50	75	100

The slow speeds apply to Standby and Light Service classification, including power plants, sub-stations, material transfer points, warehouses and assembly floors; the medium speeds to the Moderate and Heavy Duty Service classes, including machine shops, foundries, railroad shops, boiler and structural shops, lumber yards, stone yards, forge shops, etc; and the fast speeds to the Severe Duty Cycle Service class including handling of scrap, cement, crushed stone, sand, fertilizers and coal. Faster speeds can be provided for bucket or magnet handling cranes where it is necessary to meet a duty cycle.

DUTY CYCLE ANALYSIS

To aid in the selection of capacity and speeds of a crane which must handle a specified quantity of material within a certain time limit the following typical examples are shown:

EXAMPLE 1. — An overhead yard crane is to unload a car of pig iron (50 tons) in one hour. The car is spotted opposite the pig iron bin which is 10 feet wide and 30 feet long. Car is 8 feet wide and 33 feet long.

Average hoisting distance from iron in car to top of pile, 10 feet.
Average trolley travel from center of car to center of bin, 20 feet.
Average bridge travel, ¼ length of car, 8 feet.

Assume a 5 ton crane equipped with a 45″ diameter lifting magnet with a capacity of 1400 pounds. Speeds of 60 FPM hoisting and 200 FPM trolley travel and 400 FPM bridge travel. This is a Severe Duty Cycle Service classification (page 22), and speeds are selected from Table 1 on page 23.

To allow for variations, the cycle will be computed for operating only one motion at a time. A good operator should be able to reduce this computed time by combining favorable motions.

Compute the cycle starting with the magnet on the pig iron in the car (1400 pound loads average):

	Distance	Time
1. Close magnet switch		1 sec.
2. Hoist	10 ft.	10 sec.
3. Trolley travel	20 ft.	6 sec.
4. Bridge travel	8 ft.	2 sec.
5. Open magnet switch		1 sec.
6. Bridge travel	8 ft.	2 sec.
7. Trolley travel	20 ft.	6 sec.
8. Lower magnet to car pile	10 ft.	10 sec.
		38 sec.
20% for acceleration		8 sec.
Total for each 1400 pound load		46 sec.

$$\frac{2000}{1400} \times 46 = 65.7 \text{ seconds per ton}$$

$$65.7 \times 50 = 3285 \text{ seconds. } \frac{3285}{3600} = .91 \text{ hours or approx. 55 minutes.}$$

The speeds and capacity selected are ample for the cycle.

EXAMPLE 2. — An overhead bucket handling crane is required to handle 175 tons of coal from storage area to bunker per seven-hour day.

Average hoisting distance from storage to bunker, 45 feet.
Average trolley travel from storage to bunker, 35 feet.
Average bridge travel from storage to bunker, 100 feet.

Assume a 3½ ton capacity crane with a 1½ cubic yard bucket. The coal weighs 1300 pounds per cubic yard (page 136). Total load each trip 2000 pounds. Speeds are 150 FPM hoisting, 200 FPM trolley travel, and 400 FPM bridge travel. This is a Severe Duty Cycle Service classification (page 22) and speeds are selected from table on page 23.

To allow for variations, the cycle will be computed for operating only one motion at a time. A good operator should be able to reduce the computed time by combining favorable motions.

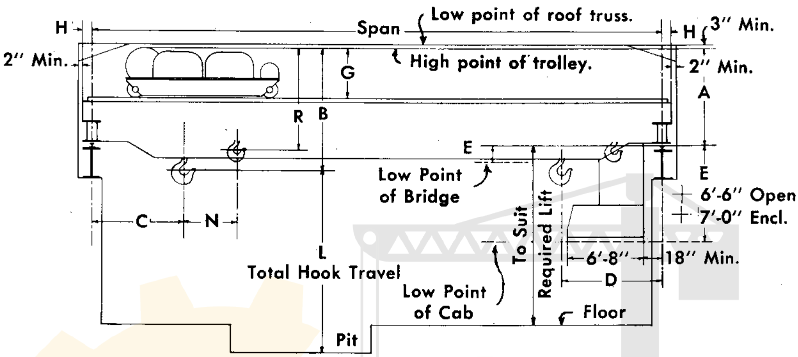
Compute the cycle starting with the bucket in the open position resting on the top of coal in storage area:

	Distance	Time
1. Close bucket	27 ft.	11 sec.
2. Hoist to clear bunker sides	45 ft.	18 sec.
3. Trolley travel	35 ft.	11 sec.
4. Bridge travel	100 ft.	15 sec.
5. Lower to coal level in bunker	5 ft.	2 sec.
6. Open bucket	27 ft.	11 sec.
7. Hoist from coal level in bunker	5 ft.	2 sec.
8. Bridge travel	100 ft.	15 sec.
9. Trolley travel	35 ft.	11 sec.
10. Lower to top of coal in storage	45 ft.	18 sec.
		114 sec.
	20% for acceleration	23 sec.
	Total for each 2000 pound load	137 sec.

$$\frac{175 \times 137}{3600} = 6.66 \text{ total hours.}$$

The capacity and speeds selected are ample for the cycle.

SECTION VI – STANDARD CLEARANCES FOR



NOTES:

Maximum wheel load figured with trolley and rated load at end of bridge. Maximum wheel load does not include impact. For impact factors see Section XIV.

See Section XIV for selection of size of runway rail.

"B" dimensions determined with paddle-type limit switch. Add 9″ for other types.

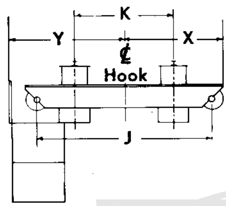
"C" and "D" dimensions based on cab and runway conductors located at right-hand end and no allowance for knee braces.

"C" and "D" dimensions make no allowance for cable reels or auxiliary equipment on crane hooks.

High point of crane from floor or pit equals "L" plus "B".

Capacity Tons	Span Ft.	A	B	C	D	E	G	H	J	K	L
5	30	4′4½″	5′4″	2′7″	3′4″	2″	2′6½″	7½″	8′0″	5′0″	38′6″
	40	4′10½″	5′4″	2′7″	3′4″	2″	2′6½″	7½″	8′0″	5′0″	38′6″
	50	4′11″	5′4″	2′7″	3′4″	2″	2′6½″	7½″	8′0″	5′0″	38′6″
Add or Deduct 7′6″ lift and 200# trolley weight for each 6″ change of "K"	60	5′0″	5′4″	2′5″	3′4″	1′3″	2′6½″	8″	9′0″	5′0″	38′6″
	70	5′2″	5′4″	2′8″	3′4″	1′5″	2′6½″	8″	10′0″	5′0″	38′6″
	80	5′5″	5′4″	2′9″	3′2″	1′8″	2′6½″	8″	11′6″	5′6″	47′1″
	90	5′10½″	5′4″	2′9″	3′2″	1′5″	2′6½″	8″	13′0″	8′0″	88′9″
	100	6′1½″	5′4″	2′9″	3′2″	1′8″	2′6½″	8¼″	14′6″	7′6″	80′0″
10	30	5′3½″	6′0″	2′5″	3′6″	4″	2′11″	7½″	8′0″	5′0″	31′4″
	40	5′3½″	6′0″	2′5″	3′6″	4″	2′11″	7½″	8′0″	5′0″	31′4″
	50	5′6½″	6′0″	2′5″	3′6″	4″	2′11″	7½″	8′0″	5′0″	31′4″
Add or Deduct 8′0″ lift and 250# trolley weight for each 6″ change of "K"	60	5′6″	6′0″	2′5″	3′6″	1′5″	2′11″	8″	9′0″	5′0″	31′4″
	70	5′11″	6′0″	2′5″	3′6″	1′3″	2′11″	8¼″	10′0″	5′0″	31′4″
	80	6′3″	6′0″	2′5″	3′3″	1′8″	2′11″	8¼″	11′6″	5′6″	40′2″
	90	6′4″	6′0″	2′5″	3′3″	1′10″	2′11″	8¼″	13′0″	6′0″	49′0″
	100	6′6½″	6′0″	2′5″	3′3″	1′8″	2′11″	8¼″	14′6″	7′6″	74′7″

OVERHEAD TRAVELING CRANES

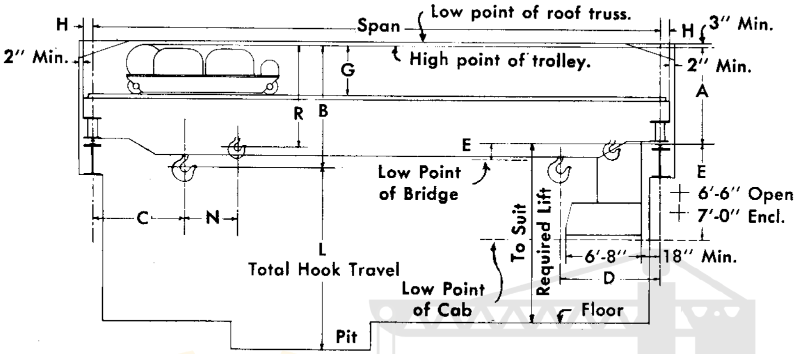


NOTES: (Continued)

These tables are based on lifts as shown by dimension "L". Additional lift may be obtained by increasing "K" and all related dimensions. See note for each capacity. Dimension "X" does not include idler girder walk or service platform. For spring bumpers, add 12″ to dimension "X". For wood bumpers, add 4″ to dimension "X". "Y" dimension based on open cab and Whiting controls. Add 2′6″ to dimension "Y" for cranes with enclosed cab.

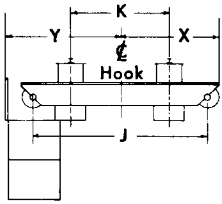
Weights shown in tables are based on plain magnetic controls, A.C. motors and brakes, wire conductors, open cab, no bumpers, Class C & D service 5 to 30 tons capacity and Class C Service above 30 tons capacity.

Capacity Tons	Span Ft.	N	R	X	Y	Max. Wheel Load	Run-way Rail	Trolley Weight	Total Crane Wt.	Type of Girder
5	30	—	—	4′10″	6′10″	13800	40#	5600	21900	Beam
	40	—	—	4′10″	6′10″	15400	40#	5600	27500	Beam
	50	—	—	4′10″	6′10″	17300	40#	5600	33100	Beam
	60	—	—	5′9″	6′11″	19400	40#	5600	35600	Box
	70	—	—	6′8″	7′0″	22600	40#	5600	42600	Box
	80	—	—	7′3″	7′4″	24200	40#	5790	49900	Box
	90	—	—	7′4″	8′9″	25400	40#	6465	59900	Box
	100	—	—	9′3″	8′6″	31100	40#	6330	70150	Box
10	30	—	—	5′4″	7′3″	20500	40#	7880	28000	Beam
	40	—	—	5′4″	7′3″	21600	40#	7880	33700	Beam
	50	—	—	5′4″	7′3″	23000	40#	7880	36000	Beam
	60	—	—	5′2″	6′11″	24200	40#	7880	39200	Box
	70	—	—	6′3″	7′0″	28700	40#	7880	47200	Box
	80	—	—	7′4″	7′4″	31200	40#	8100	55400	Box
	90	—	—	8′6″	8′0″	35200	60#	8330	64800	Box
	100	—	—	9′3″	8′6″	39800	60#	9000	77900	Box



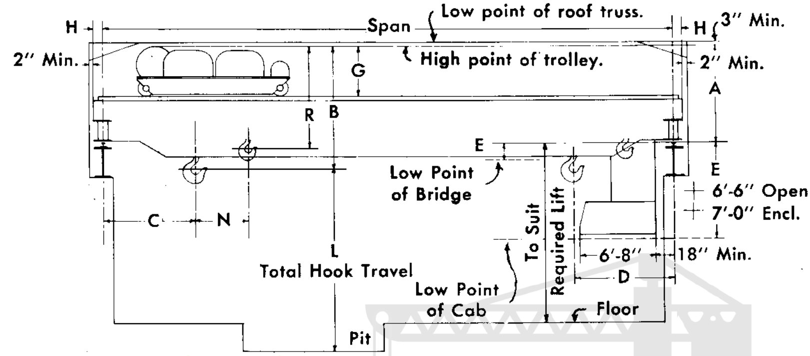
See Notes, Pages 26 and 27

Capacity Tons	Span Ft.	A	B	C	D	E	G	H	J	K	L
15 Add or Deduct 4′9″ lift and 250# trolley weight for each 6″ change of "K"	30	5′3½″	6′8″	2′10″	3′6″	2″	2′11″	8¼″	9′6″	5′6″	22′7″
	40	5′4″	6′8″	2′10″	3′6″	2″	2′11″	8¼″	9′6″	5′6″	22′7″
	50	5′11″	6′8″	2′10″	3′6″	10″	2′11″	8¼″	9′6″	5′6″	22′7″
	60	5′11″	6′8″	2′10″	3′6″	1′3″	2′11″	8¼″	9′6″	5′6″	22′7″
	70	5′11″	6′8″	2′10″	3′6″	1′8″	2′11″	8¼″	10′0″	5′6″	22′7″
	80	6′4″	6′8″	2′10″	3′4″	1′10″	2′11″	8¼″	11′6″	5′6″	22′7″
	90	6′4″	6′8″	2′10″	3′4″	1′10″	2′11″	8¼″	13′0″	7′6″	41′3″
	100	6′8″	6′8″	2′10″	3′4″	2′4″	2′11″	8¾″	14′6″	8′6″	51′1″
15 5 Aux. Add or Deduct 4′9″ lift and 400# trolley weight for each 6″ change of "K"	30	5′5½″	6′9″	3′8″	7′11″	2″	3′1″	8¼″	9′6″	5′6″	22′7″
	40	5′9″	6′9″	3′8″	7′11″	2″	3′1″	8¼″	9′6″	5′6″	22′7″
	50	6′1″	6′9″	3′8″	7′11″	10″	3′1″	8¼″	9′6″	5′6″	22′7″
	60	6′1″	6′9″	3′5″	7′11″	1′3″	3′1″	8¼″	9′6″	5′6″	22′7″
	70	6′1″	6′9″	3′5″	7′11″	1′8″	3′1″	8¼″	10′0″	5′6″	22′7″
	80	6′6″	6′9″	3′5″	7′11″	1′10″	3′1″	8¼″	11′6″	5′6″	22′7″
	90	6′6″	6′9″	3′5″	7′11″	1′10″	3′1″	8¼″	13′0″	7′6″	41′6″
	100	6′10″	6′9″	3′5″	7′11″	2′4″	3′1″	8¾″	14′6″	8′6″	51′1″
20 Add or Deduct 4′0″ lift and 300# trolley weight for each 6″ change of "K"	30	5′4″	6′9″	2′10″	3′6″	2″	2′11″	8¼″	9′6″	5′6″	20′1″
	40	5′7″	6′9″	2′10″	3′6″	2″	2′11″	8¼″	9′6″	5′6″	20′1″
	50	5′11″	6′9″	2′10″	3′6″	1′2″	2′11″	8¼″	9′6″	5′6″	20′1″
	60	5′11″	6′9″	2′10″	3′6″	1′8″	2′11″	8¼″	9′6″	5′6″	20′1″
	70	6′3″	6′9″	2′10″	3′6″	1′8″	2′11″	8¾″	10′0″	5′6″	20′1″
	80	6′6″	6′9″	2′10″	3′4″	1′8″	2′11″	8¾″	11′6″	5′6″	20′1″
	90	6′6″	6′9″	2′10″	3′4″	1′9″	2′11″	8¾″	13′0″	7′6″	37′3″
	100	6′8″	6′9″	2′10″	3′4″	2′7″	2′11″	8¾″	14′6″	8′6″	46′2″
20 5 Aux. Add or Deduct 4′0″ lift and 500# trolley weight for each 6″ change of "K"	30	5′6″	6′10″	3′5″	7′11″	2″	3′1″	8¼″	9′6″	5′6″	20′1″
	40	5′9″	6′10″	3′5″	7′11″	2″	3′1″	8¼″	9′6″	5′6″	20′1″
	50	6′1½″	6′10″	3′5″	7′11″	1′2″	3′1″	8¼″	9′6″	5′6″	20′1″
	60	6′1½″	6′10″	3′5″	7′11″	1′8″	3′1″	8¼″	9′6″	5′6″	20′1″
	70	6′5½″	6′10″	3′5″	7′11″	1′8″	3′1″	8¾″	10′0″	5′6″	20′1″
	80	6′8½″	6′10″	3′5″	7′11″	1′8″	3′1″	8¾″	11′6″	5′6″	20′1″
	90	6′8½″	6′10″	3′5″	7′11″	1′9″	3′1″	8¾″	13′0″	7′6″	34′6″
	100	6′10½″	6′10″	3′5″	7′11″	2′7″	3′1″	8¾″	14′6″	8′6″	42′6″



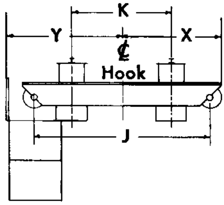
See Notes, Pages 26 and 27

Capacity Tons	Span Ft.	N	R	X	Y	Max. Wheel Load	Run-way Rail	Trolley Weight	Total Crane Wt.	Type of Girder
15	30	—	—	5′9″	7′3″	25300	40#	8960	31000	Beam
	40	—	—	5′9″	7′3″	26800	40#	8960	37000	Beam
	50	—	—	5′8″	7′1″	29500	40#	8960	39300	Box
	60	—	—	5′7″	7′2″	31200	40#	8960	43400	Box
	70	—	—	6′0″	7′3″	33800	60#	8960	49100	Box
	80	—	—	7′4″	7′4″	39600	60#	8960	57500	Box
	90	—	—	7′9″	8′6″	41000	60#	9860	68700	Box
	100	—	—	8′2″	9′0″	44000	60#	10300	86700	Box
15 5 Aux.	30	4′10″	5′10″	5′9″	7′3″	27100	40#	12900	35000	Beam
	40	4′10″	5′10″	5′9″	7′3″	28600	40#	12900	41000	Beam
	50	4′10″	5′10″	5′8″	7′1″	31250	40#	12900	43300	Box
	60	4′10″	5′10″	5′1″	7′2″	33000	40#	12900	47400	Box
	70	4′10″	5′10″	6′0″	7′2″	35500	60#	12900	53200	Box
	80	4′10″	5′10″	7′4″	7′4″	41350	60#	12900	61500	Box
	90	4′10″	5′10″	7′9″	8′6″	43200	60#	14300	72700	Box
	100	4′10″	5′10″	8′2″	9′0″	46750	60#	15000	90700	Box
20	30	—	—	5′10½″	7′3″	33500	60#	9500	37100	Beam
	40	—	—	5′10½″	7′3″	35000	60#	9500	42300	Beam
	50	—	—	5′10½″	7′3″	36000	60#	9500	43500	Box
	60	—	—	5′10½″	7′3″	36900	60#	9500	45800	Box
	70	—	—	6′4½″	7′3″	41600	60#	9500	55600	Box
	80	—	—	7′4″	7′4″	48200	60#	9500	63600	Box
	90	—	—	7′9″	8′6″	46600	60#	10560	80300	Box
	100	—	—	8′2″	9′0″	51600	80#	11100	94000	Box
20 5 Aux.	30	4′10″	6′0″	5′10½″	7′3″	35900	60#	14700	42300	Beam
	40	4′10″	6′0″	5′10½″	7′3″	37600	60#	14700	47500	Beam
	50	4′10″	6′0″	5′10½″	7′3″	38600	60#	14700	48700	Box
	60	4′10″	6′0″	5′10½″	7′3″	39500	60#	14700	54300	Box
	70	4′10″	6′0″	6′4½″	7′3″	44200	60#	14700	60300	Box
	80	4′10″	6′0″	7′4″	7′4″	50800	60#	14700	68800	Box
	90	4′10″	6′0″	7′9″	8′6″	50600	60#	16520	86500	Box
	100	4′10″	6′0″	8′2″	9′0″	54800	80#	17420	100200	Box



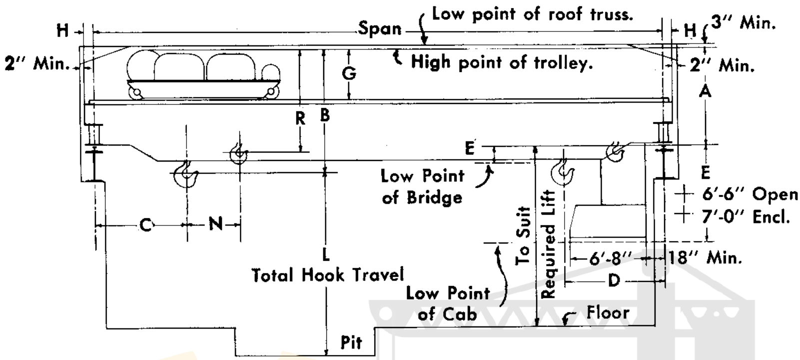
See Notes, Pages 26 and 27

Capacity Tons	Span Ft.	A	B	C	D	E	G	H	J	K	L
25 Add or Deduct 2′7″ lift and 300# trolley weight for each 6″ change of "K"	30	5′6″	7′1″	3′1″	3′7″	2″	3′1″	8¼″	12′0″	8′0″	27′9″
	40	6′0″	7′1″	3′1″	3′7″	3″	3′1″	8¾″	12′0″	8′0″	27′9″
	50	6′4″	7′1″	3′1″	3′7″	9½″	3′1″	8¾″	12′0″	8′0″	27′9″
	60	6′4″	7′1″	3′1″	3′4″	1′3½″	3′1″	8¾″	12′0″	8′0″	27′9″
	70	6′5″	7′1″	3′1″	3′4″	1′9″	3′1″	8¾″	12′6″	8′0″	27′9″
	80	6′8″	7′1″	3′1″	3′4″	1′9″	3′1″	8¾″	12′6″	8′0″	27′9″
	90	6′8¼″	7′1″	3′1″	3′4″	1′9″	3′1″	8¾″	13′0″	8′0″	27′9″
	100	7′3″	7′1″	3′1″	3′4″	2′1″	3′1″	8¾″	14′6″	8′0″	27′9″
25 5 Aux. Add or Deduct 2′7″ lift and 500# trolley weight for each 6″ change of "K"	30	5′9″	7′1″	3′7″	7′7″	2″	3′3″	8¼″	12′0″	8′0″	27′9″
	40	6′3″	7′1″	3′7″	7′7″	3″	3′3″	8¾″	12′0″	8′0″	27′9″
	50	6′7″	7′1″	3′7″	7′7″	9½″	3′3″	8¾″	12′0″	8′0″	27′9″
	60	6′7″	7′1″	3′7″	7′10″	1′3½″	3′3″	8¾″	12′0″	8′0″	27′9″
	70	6′8″	7′1″	3′7″	7′10″	1′9″	3′3″	8¾″	12′6″	8′0″	27′9″
	80	6′11″	7′1″	3′7″	7′10″	1′9″	3′3″	8¾″	12′6″	8′0″	27′9″
	90	6′11″	7′1″	3′7″	7′10″	1′9″	3′3″	8¾″	13′0″	8′0″	27′9″
	100	7′6″	7′1″	3′2″	7′10″	2′1″	3′3″	8¾″	14′6″	8′0″	27′9″
30 Add or Deduct 2′7″ lift and 300# trolley weight for each 6″ change of "K"	30	5′6″	7′1″	3′1″	3′7″	3″	3′1″	8¾″	12′0″	8′0″	27′9″
	40	6′0″	7′1″	3′1″	3′7″	3″	3′1″	8¾″	12′0″	8′0″	27′9″
	50	6′4½″	7′1″	3′1″	3′7″	9″	3′1″	8¾″	12′0″	8′0″	27′9″
	60	6′4½″	7′1″	3′1″	3′4″	1′3″	3′1″	8¾″	12′0″	8′0″	27′9″
	70	6′5½″	7′1″	3′1″	3′4″	1′8″	3′1″	8¾″	12′6″	8′0″	27′9″
	80	6′11½″	7′1″	3′1″	3′4″	1′5″	3′1″	8¾″	12′6″	8′0″	27′9″
	90	6′11½″	7′1″	3′1″	3′4″	2′0″	3′1″	8¾″	13′0″	8′0″	27′9″
	100	7′3½″	7′1″	3′1″	3′4″	2′2″	3′1″	8¾″	14′6″	8′0″	27′9″
30 5 Aux. Add or Deduct 2′7″ lift and 500# trolley weight for each 6″ change of "K"	30	5′8″	7′1″	3′7″	7′7″	3″	3′3″	8¾″	12′0″	8′0″	27′9″
	40	6′2″	7′1″	3′7″	7′7″	3″	3′3″	8¾″	12′0″	8′0″	27′9″
	50	6′7″	7′1″	3′7″	7′7″	9″	3′3″	8¾″	12′0″	8′0″	27′9″
	60	6′7″	7′1″	3′7″	7′10″	1′3″	3′3″	8¾″	12′0″	8′0″	27′9″
	70	6′8″	7′1″	3′7″	7′10″	1′8″	3′3″	8¾″	12′6″	8′0″	27′9″
	80	7′2″	7′1″	3′7″	7′10″	1′5″	3′3″	8¾″	12′6″	8′0″	27′9″
	90	7′2″	7′1″	3′2″	7′10″	2′0″	3′3″	8¾″	13′0″	8′0″	27′9″
	100	7′6″	7′1″	3′2″	7′10″	2′2″	3′3″	9½″	14′6″	8′0″	27′9″



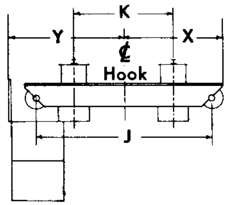
See Notes, Pages 26 and 27

Capacity Tons	Span Ft.	N	R	X	Y	Max. Wheel Load	Run-way Rail	Trolley Weight	Total Crane Wt.	Type of Girder
25	30	—	—	7′0″	9′0″	38200	60#	11500	39000	Beam
	40	—	—	7′0″	9′0″	40600	60#	11500	47000	Beam
	50	—	—	7′0″	9′0″	40000	60#	11500	45000	Box
	60	—	—	7′0″	9′0″	43800	60#	11500	51000	Box
	70	—	—	7′4½″	9′0″	48400	60#	11500	61000	Box
	80	—	—	7′1½″	9′0″	54000	80#	11500	70500	Box
	90	—	—	7′7″	9′0″	54300	80#	11500	89900	Box
	100	—	—	7′10″	9′3″	53100	80#	11500	99300	Box
25 5 Aux.	30	4′10″	5′11″	7′0″	9′0″	41600	60#	18300	45800	Beam
	40	4′10″	5′11″	7′0″	9′0″	44000	60#	18300	53800	Beam
	50	4′10″	5′11″	7′0″	9′0″	43400	60#	18300	51800	Box
	60	4′10″	5′11″	7′0″	9′0″	47200	60#	18300	57800	Box
	70	4′10″	5′11″	7′4½″	9′0″	51800	60#	18300	67800	Box
	80	4′10″	5′11″	7′1½″	9′0″	57400	80#	18300	77300	Box
	90	4′10″	5′11″	7′7″	9′0″	57700	80#	18300	96700	Box
	100	4′10″	5′11″	7′10″	9′3″	56500	80#	18300	106100	Box
30	30	—	—	7′0″	9′0″	44200	60#	11600	41600	Beam
	40	—	—	7′0″	9′0″	46000	60#	11600	49000	Beam
	50	—	—	7′0″	9′0″	46300	60#	11600	50000	Box
	60	—	—	7′0″	9′0″	48900	60#	11600	56900	Box
	70	—	—	7′4½″	9′0″	53200	60#	11600	67100	Box
	80	—	—	7′2″	9′0″	56000	80#	11600	80700	Box
	90	—	—	7′8″	9′3″	59700	80#	11600	93000	Box
	100	—	—	7′10″	9′3″	62000	80#	11600	103800	Box
30 5 Aux.	30	4′10″	5′11″	7′0″	9′0″	47400	60#	18300	48200	Beam
	40	4′10″	5′11″	7′0″	9′0″	49200	60#	18300	55700	Beam
	50	4′10″	5′11″	7′0″	9′0″	49500	60#	18300	56700	Box
	60	4′10″	5′11″	7′0″	9′0″	52100	60#	18300	63900	Box
	70	4′10″	5′11″	7′4½″	9′0″	56400	60#	18300	74800	Box
	80	4′10″	5′11″	7′2″	9′0″	59200	80#	18300	87700	Box
	90	4′10″	5′11″	7′8″	9′3″	62900	80#	18300	99700	Box
	100	4′10″	5′11″	7′10″	9′3″	65200	80#	18300	110000	Box



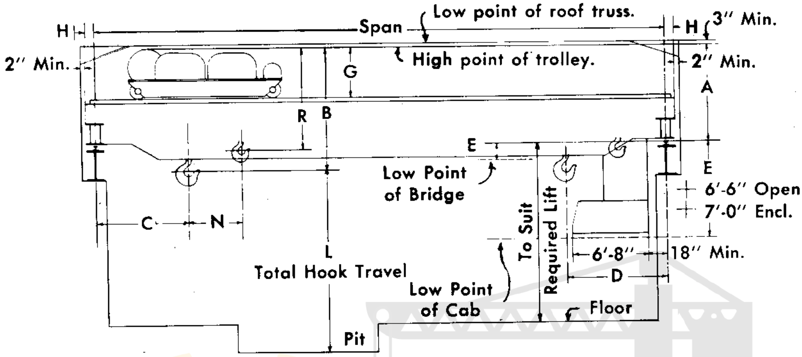
See Notes, Pages 26 and 27

Capacity Tons	Span Ft.	A	B	C	D	E	G	H	J	K	L
40	30	7′5½″	6′10″	4′9″	8′0″	3″	4′0″	8¾″	12′0″	8′0″	40′8″
10 Aux.	40	7′4″	6′10″	4′9″	8′0″	7″	4′0″	9½″	12′6″	8′0″	40′8″
Add or Deduct	50	7′6″	6′10″	4′9″	8′0″	11″	4′0″	9½″	12′6″	8′0″	40′8″
4′2″ lift and	60	7′11″	6′10″	4′9″	8′0″	6″	4′0″	9½″	12′6″	8′0″	40′8″
700# trolley	70	7′11″	6′10″	4′9″	8′0″	1′5″	4′0″	9½″	12′6″	8′0″	40′8″
weight for each	80	8′0″	6′10″	4′9″	8′0″	1′11″	4′0″	9½″	12′6″	8′0″	40′8″
6″ change of	90	8′2″	6′10″	4′9″	8′0″	2′1″	4′0″	10¼″	13′0″	8′0″	40′8″
"K"	100	8′6″	6′10″	4′9″	8′0″	2′7″	4′0″	10¼″	14′6″	8′0″	40′8″
50	30	7′6″	6′10″	4′9″	8′0″	3″	4′0″	9½″	12′0″	8′0″	35′10″
10 Aux.	40	7′6″	6′10″	4′9″	8′0″	7″	4′0″	9½″	12′6″	8′0″	35′10″
Add or Deduct	50	7′9″	6′10″	4′9″	8′0″	1′0″	4′0″	9½″	12′6″	8′0″	35′10″
4′2″ lift and	60	8′0″	6′10″	4′9″	8′0″	1′1″	4′0″	9½″	12′6″	8′0″	35′10″
700# trolley	70	8′3″	6′10″	4′9″	8′0″	1′4″	4′0″	10¼″	12′6″	8′0″	35′10″
weight for each	80	8′3″	6′10″	4′9″	8′0″	2′1″	4′0″	10¼″	12′6″	8′0″	35′10″
6″ change of	90	8′3″	6′10″	4′9″	8′0″	2′6″	4′0″	10¼″	13′0″	8′0″	35′10″
"K"	100	8′7″	6′10″	4′9″	8′0″	2′10″	4′0″	10¼″	14′6″	8′0″	35′10″
60	30	7′10″	9′2″	4′5″	8′1″	5″	4′4″	9½″	13′0″	9′0″	40′0″
10 Aux.	40	8′4″	9′2″	4′5″	8′1″	7″	4′4″	10¼″	13′6″	9′0″	40′0″
Add or Deduct	50	8′6″	9′2″	4′5″	8′1″	7″	4′4″	10¼″	13′6″	9′0″	40′0″
3′6″ lift and	60	8′8″	9′2″	4′5″	8′1″	9″	4′4″	10¼″	14′0″	9′0″	40′0″
900# trolley	70	8′8″	9′2″	4′5″	8′1″	1′10″	4′4″	10¼″	14′0″	9′0″	40′0″
weight for each	80	8′8″	9′2″	4′5″	8′1″	2′4″	4′4″	10¼″	14′0″	9′0″	40′0″
6″ change of	90	9′0″	9′2″	4′5″	8′1″	2′10″	4′4″	10¼″	14′0″	9′0″	40′0″
"K"	100	9′0″	9′2″	4′5″	8′1″	2′10″	4′4″	10¼″	14′6″	9′0″	40′0″
75	40	9′5″	7′2″	4′3″	9′6″	6″	4′11″	10¼″	14′6″	10′0″	38′0″
15 Aux.	50	9′9″	7′2″	4′3″	9′6″	10″	4′11″	10¼″	14′6″	10′0″	38′0″
Add or Deduct	60	9′9″	7′2″	4′3″	9′6″	11″	4′11″	10¼″	14′6″	10′0″	38′0″
3′6″ lift and	70	9′9″	7′2″	4′3″	9′6″	1′8″	4′11″	10¼″	14′6″	10′0″	38′0″
1250# trolley	80	10′3″	7′2″	4′3″	9′6″	1′10″	4′11″	10¼″	14′6″	10′0″	38′0″
weight for each	90	10′4″	7′2″	4′3″	9′6″	2′1″	4′11″	11″	14′6″	10′0″	38′0″
6″ change of	100	10′4″	7′2″	4′3″	9′6″	3′0″	4′11″	11″	14′6″	10′0″	38′0″
"K"	110	10′6″	7′2″	4′3″	9′6″	3′0″	4′11″	11″	16′0″	10′6″	41′6″
100	40	9′10″	7′4″	4′6″	8′2″	4″	5′0½″	11″	16′0″	12′0″	46′6″
15 Aux.	50	10′2″	7′4″	4′6″	8′2″	7″	5′0½″	11″	16′0″	12′0″	46′6″
Add or Deduct	60	10′4″	7′4″	4′6″	8′2″	1′6″	5′0½″	11″	16′6″	12′0″	46′6″
2′9″ lift.	70	10′5″	7′4″	4′6″	8′2″	1′9″	5′0½″	11½″	16′6″	12′0″	46′6″



See Notes, Pages 26 and 27

Capacity Tons	Span Ft.	N	R	X	Y	Max. Wheel Load	Run-way Rail	Trolley Weight	Total Crane Wt.	Type of Girder
40 10 Aux.	30	4′11″	7′6″	7′3″	9′0″	57000	80#	31700	64500	Beam
	40	4′11″	7′6″	7′6″	9′0″	65000	80#	31700	72000	Box
	50	4′11″	7′6″	7′6″	9′0″	66100	80#	31700	78400	Box
	60	4′11″	7′6″	7′6″	9′0″	71000	80#	31700	91000	Box
	70	4′11″	7′6″	7′6″	9′0″	76000	100#	31700	99700	Box
	80	4′11″	7′6″	7′6″	9′0″	80000	100#	31700	118500	Box
	90	4′11″	7′6″	7′10″	9′3″	84900	100#	31700	132000	Box
	100	4′11″	7′6″	7′10″	9′3″	88000	100#	31700	145000	Box
50 10 Aux.	30	4′11″	7′6″	7′3″	9′0″	70000	80#	31900	65600	Beam
	40	4′11″	7′6″	7′6″	9′0″	74000	100#	31900	74000	Box
	50	4′11″	7′6″	7′6″	9′0″	78000	100#	31900	81800	Box
	60	4′11″	7′6″	7′6″	9′0″	82200	100#	31900	91600	Box
	70	4′11″	7′6″	7′6″	9′3″	86300	100#	31900	105000	Box
	80	4′11″	7′6″	7′6″	9′3″	90000	135#	31900	119500	Box
	90	4′11″	7′6″	7′10″	9′3″	94700	135#	31900	132500	Box
	100	4′11″	7′6″	7′10″	9′3″	98200	175#	31900	146000	Box
60 10 Aux.	30	5′0″	7′7″	7′10″	9′6″	81800	100#	38050	76500	Beam
	40	5′0″	7′7″	8′1″	9′6″	87300	100#	38050	85000	Box
	50	5′0″	7′7″	8′1″	9′6″	91000	135#	38050	95000	Box
	60	5′0″	7′7″	8′6″	9′6″	95600	135#	38050	104800	Box
	70	5′0″	7′7″	8′6″	9′9″	99600	175#	38050	116900	Box
	80	5′0″	7′7″	8′6″	9′9″	104300	175#	38050	130700	Box
	90	5′0″	7′7″	8′6″	9′9″	107800	175#	38050	143400	Box
	100	5′0″	7′7″	8′9″	10′0″	113000	175#	38050	164000	Box
75 15 Aux.	40	5′9″	7′8″	8′7½″	10′3″	104600	175#	45400	96000	Box
	50	5′9″	7′8″	8′7½″	10′3″	109600	175#	45400	105800	Box
	60	5′9″	7′8″	8′7½″	10′3″	114200	175#	45400	117500	Box
	70	5′9″	7′8″	8′7½″	10′3″	120000	175#	45400	132000	Box
	80	5′9″	7′8″	8′7½″	10′3″	124700	175#	45400	145800	Box
	90	5′9″	7′8″	8′9″	10′5″	130000	175#	45400	168000	Box
	100	5′9″	7′8″	8′9″	10′5″	137500	175#	45400	182000	Box
	110	5′9″	7′8″	9′6″	10′11″	140300	175#	46500	201000	Box
100 15 Aux.	40	4′1″	7′10″	9′6″	11′0″	134300	175#	61050	117200	Box
	50	4′1″	7′10″	9′6″	11′0″	141300	175#	61050	131500	Box
	60	4′1″	7′10″	9′9″	11′3″	147000	175#	61050	143700	Box
	70	4′1″	7′10″	10′0″	11′3″	153700	175#	61050	162000	Box



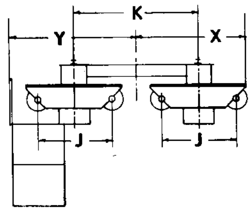
See Notes, Pages 26 and 27

Additional notes for cranes with bogie trucks:

Weights based on fixed bogie trucks

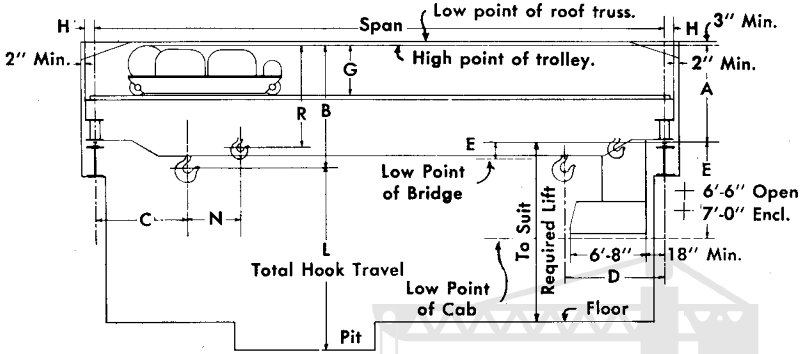
Add 1000# to max. wheel load for equalizing bogie trucks.
Add 6000# to crane weight for equalizing bogie trucks.
171# rail may be used wherever 175# is shown in tables.

Capacity Tons	Span Ft.	A	B	C	D	E	G	H	J	K	L
60	90	9′0″	9′2″	4′5″	8′1″	2′10″	4′4″	8¾″	5′0″	9′6″	43′6″
10 Aux.	100	9′0″	9′2″	4′5″	8′1″	3′0″	4′4″	8¾″	5′0″	9′6″	43′6″
See 60/10 p. 32											
75	50	9′9″	7′2″	4′3″	9′6″	10″	4′11″	8¾″	4′6″	10′0″	38′0″
15 Aux.	60	9′9″	7′2″	4′3″	9′6″	11″	4′11″	8¾″	4′6″	10′0″	38′0″
Add or Deduct	70	9′9″	7′2″	4′3″	9′6″	1′8″	4′11″	8¾″	5′0″	10′0″	38′0″
3′6″ lift and	80	10′3″	7′2″	4′3″	9′6″	1′10″	4′11″	8¾″	5′0″	10′0″	38′0″
1250# trolley	90	10′4″	7′2″	4′3″	9′6″	2′1″	4′11″	9½″	5′0″	10′0″	38′0″
weight for each 6″ change of	100	10′4″	7′2″	4′3″	9′6″	3′0″	4′11″	9½″	5′0″	10′0″	38′0″
"K"	110	10′6″	7′2″	4′3″	9′6″	3′0″	4′11″	9½″	5′6″	10′6″	41′6″
100	40	9′10″	7′4″	4′6″	8′2″	4″	5′0½″	9½″	4′6″	12′0″	46′6″
15 Aux.	50	10′2″	7′4″	4′6″	8′2″	7″	5′0½″	9½″	4′6″	12′0″	46′6″
Add or Deduct	60	10′4″	7′4″	4′6″	8′2″	1′6″	5′0½″	9½″	4′6″	12′0″	46′6″
2′9″ lift and	70	10′5″	7′4″	4′6″	8′2″	1′9″	5′0½″	9½″	5′0″	12′0″	46′6″
1250# trolley	80	10′6″	7′4″	4′6″	8′2″	2′0″	5′0½″	9½″	5′0″	12′0″	46′6″
weight for each	90	10′7″	7′4″	4′6″	8′2″	2′7″	5′0½″	10¼″	5′6″	12′0″	46′6″
6″ change of	100	10′8″	7′4″	4′6″	8′2″	3′0″	5′0½″	10¼″	5′6″	12′0″	46′6″
"K"	110	11′0″	7′4″	4′6″	8′2″	3′0″	5′0½″	10¼″	5′6″	12′0″	46′6″
	120	11′9″	7′4″	4′6″	8′2″	3′0″	5′0½″	10¼″	5′6″	12′0″	46′6″
125	50	10′0″	7′10″	5′3″	8′4″	1′7″	5′2″	10¼″	4′6″	13′0″	43′0″
20 Aux.	60	10′6″	7′10″	5′3″	8′4″	1′7″	5′2″	10¼″	5′0″	13′0″	43′0″
Add or Deduct	70	11′0″	7′10″	5′3″	8′4″	2′1″	5′2″	10¼″	5′0″	13′0″	43′0″
3′6″ lift and	80	11′1″	7′10″	5′3″	8′4″	2′5″	5′2″	10¼″	5′0″	13′0″	43′0″
1450# trolley	90	11′2″	7′10″	5′3″	8′4″	2′8″	5′2″	10¼″	5′6″	13′0″	43′0″
weight for each	100	11′3″	7′10″	5′3″	8′4″	2′8″	5′2″	10¼″	5′6″	13′0″	43′0″
6″ change of	110	11′8″	7′10″	5′3″	8′4″	3′2″	5′2″	10¼″	5′6″	13′0″	43′0″
"K"	120	12′1″	7′10″	5′3″	8′4″	3′2″	5′2″	10¼″	5′6″	13′0″	43′0″



See Notes, Pages 26, 27 and 34

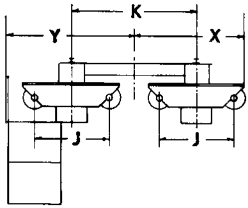
Capacity Tons	Span Ft.	N	R	X	Y	Max. Wheel Load	Run-way Rail	Trolley Weight	Total Crane Wt.	Type of Girder
60 10 Aux.	90	5′0″	7′7″	8′6″	9′10″	54700	80#	39000	147000	Box
	100	5′0″	7′7″	8′6″	9′11″	57300	80#	39000	165400	Box
75 15 Aux.	50	5′9″	7′8″	8′3″	10′1″	55600	80#	45400	108000	Box
	60	5′9″	7′8″	8′3″	10′1″	57500	80#	45400	120500	Box
	70	5′9″	7′8″	8′6″	10′1″	60600	80#	45400	137000	Box
	80	5′9″	7′8″	8′6″	10′1″	63500	80#	45400	150900	Box
	90	5′9″	7′8″	8′9″	10′4″	66400	80#	45400	169000	Box
	100	5′9″	7′8″	8′10″	10′4″	69200	80#	45400	185000	Box
	110	5′9″	7′8″	9′0″	10′7″	72100	100#	46500	202000	Box
100 15 Aux.	40	4′1″	7′10″	9′6″	11′1″	67500	100#	61050	117200	Box
	50	4′1″	7′10″	9′6″	11′1″	71000	100#	61050	134000	Box
	60	4′1″	7′10″	9′6″	11′1″	73600	100#	61050	144700	Box
	70	4′1″	7′10″	9′9″	11′4″	77000	100#	61050	160000	Box
	80	4′1″	7′10″	9′9″	11′4″	79000	100#	61050	173100	Box
	90	4′1″	7′10″	10′1″	11′7″	83000	100#	61050	196700	Box
	100	4′1″	7′10″	10′1″	11′7″	85700	100#	61050	216100	Box
	110	4′1″	7′10″	10′1″	11′7″	88100	135#	61050	235400	Box
	120	4′1″	7′10″	10′1″	11′7″	91300	135#	61050	255200	Box
125 20 Aux.	50	4′2½″	8′0″	10′1″	11′7″	84800	100#	63400	144500	Box
	60	4′2½″	8′0″	10′4″	11′10″	88000	135#	63400	161500	Box
	70	4′2½″	8′0″	10′4″	11′10″	91000	135#	63400	175700	Box
	80	4′2½″	8′0″	10′4″	11′10″	94000	135#	63400	194200	Box
	90	4′2½″	8′0″	10′4″	11′10″	97500	175#	63400	216000	Box
	100	4′2½″	8′0″	10′4″	11′10″	100500	175#	63400	235400	Box
	110	4′2½″	8′0″	10′4″	11′10″	104000	175#	63400	257600	Box
	120	4′2½″	8′0″	10′4″	11′10″	108000	175#	63400	282000	Box



See Notes, Pages 26, 27 and 34

Capacity Tons	Span Ft.	A	B	C	D	E	G	H	J	K	L
150 25 Aux. Add or Deduct 2'7" lift and 1750# trolley weight for each 6" change of "K"	50	11'0"	8'6"	6'6"	8'0"	1'5"	5'8"	10¼"	4'6"	15'0"	51'9"
	60	11'6"	8'6"	6'6"	8'0"	1'6"	5'8"	10¼"	5'0"	15'0"	51'9"
	70	11'9"	8'6"	6'6"	8'0"	1'11"	5'8"	10¼"	5'0"	15'0"	51'9"
	80	11'9"	8'6"	6'6"	8'0"	2'5"	5'8"	10¼"	5'6"	15'0"	51'9"
	90	12'0"	8'6"	6'6"	8'0"	2'7"	5'8"	10¼"	5'6"	15'0"	51'9"
	100	12'3"	8'6"	6'6"	8'0"	2'8"	5'8"	10¼"	5'6"	15'0"	51'9"
	110	12'7"	8'6"	6'6"	8'0"	3'2"	5'8"	10¼"	5'6"	15'0"	51'9"
	120	12'10"	8'6"	6'6"	8'0"	3'0"	5'8"	10¼"	5'6"	15'0"	51'9"
200 25 Aux. Add or Deduct 3'0" lift and 2400# trolley weight for each 6" change of "K"	50	13'6"	14'8"	7'0"	9'0"	10"	6'8"	11"	5'6"	17'0"	59'0"
	60	13'9"	14'8"	7'0"	9'0"	1'7"	6'8"	11"	5'6"	17'0"	59'0"
	70	14'0"	14'8"	7'0"	9'0"	1'4"	6'8"	11"	5'6"	17'0"	59'0"
	80	14'4"	14'8"	7'0"	9'0"	1'7"	6'8"	11"	5'6"	17'0"	59'0"
	90	14'9"	14'8"	7'0"	9'0"	1'11"	6'8"	11½"	6'0"	17'0"	59'0"
	100	15'0"	14'8"	7'0"	9'0"	1'7"	6'8"	11½"	6'0"	17'0"	59'0"
	110	15'3"	14'8"	7'0"	9'0"	1'5"	6'8"	11½"	6'0"	17'0"	59'0"
	120	15'3"	14'8"	7'0"	9'0"	1'5"	6'8"	11½"	6'0"	17'0"	59'0"
250 25 Aux. Add or Deduct 3'6" lift and 2800# trolley weight for each 6" change of "K"	50	15'6"	15'0"	8'3"	8'9"	1'1"	8'0"	11½"	6'0"	18'0"	90'0"
	60	15'9"	15'0"	8'3"	8'9"	1'5"	8'0"	11½"	6'0"	18'0"	90'0"
	70	16'9"	15'0"	8'3"	8'9"	1'4"	8'0"	12"	*	18'0"	90'0"
	80	17'0"	15'0"	8'3"	8'9"	1'3"	8'0"	12"	*	18'0"	90'0"
	90	17'0"	15'0"	8'3"	8'9"	1'3"	8'0"	12"	*	18'0"	90'0"
	100	17'3"	15'0"	8'3"	8'9"	1'0"	8'0"	12"	*	18'0"	90'0"
	110	17'6"	15'0"	8'3"	8'9"	9"	8'0"	12"	*	18'0"	90'0"
	120	17'6"	15'0"	8'3"	8'9"	9"	8'0"	12"	*	18'0"	90'0"

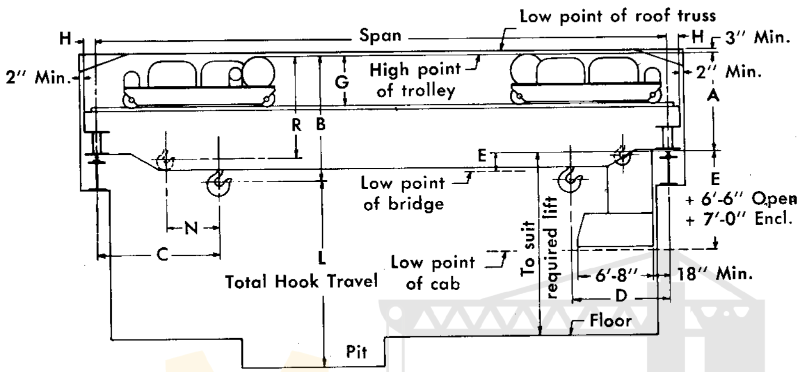
* Wheel spacing = 4'6"-3'0"-4'6"-6'0"-4'6"-3'0"-4'6"



See Notes, Pages 26, 27 and 34

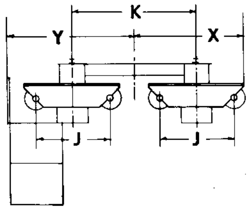
Capacity Tons	Span Ft.	N	R	X	Y	Max. Wheel Load	Run-way Rail	Trolley Weight	Total Crane Wt.	Type of Girder
150 25 Aux.	50	4′6″	8′11″	11′1″	12′7″	97200	175#	79000	168000	Box
	60	4′6″	8′11″	11′4″	12′10″	102800	175#	79000	183000	Box
	70	4′6″	8′11″	11′4″	12′10″	105700	175#	79000	201000	Box
	80	4′6″	8′11″	11′7″	13′1″	109100	175#	79000	219500	Box
	90	4′6″	8′11″	11′7″	13′1″	113300	175#	79000	242000	Box
	100	4′6″	8′11″	11′7″	13′1″	116200	175#	79000	261500	Box
	110	4′6″	8′11″	11′7″	13′1″	120000	175#	79000	287500	Box
	120	4′6″	8′11″	11′7″	13′1″	123700	175#	79000	310000	Box
200 25 Aux.	50	4′3″	10′6″	13′1″	14′3″	133000	175#	128200	240000	Box
	60	4′3″	10′6″	13′1″	14′3″	138500	175#	128200	258500	Box
	70	4′3″	10′6″	13′1″	14′3″	143400	175#	128200	281500	Box
	80	4′3″	10′6″	13′1″	14′3″	147000	175#	128200	301000	Box
	90	4′3″	10′6″	13′4″	14′6″	153000	175#	128200	334000	Box
	100	4′3″	10′6″	13′4″	14′6″	158000	175#	128200	361000	Box
	110	4′3″	10′6″	13′4″	14′6″	162500	175#	128200	389500	Box
	120	4′3″	10′6″	13′4″	14′6″	167800	175#	128200	423000	Box
250 25 Aux.	50	3′5″	13′0″	13′10″	15′0″	154500	175#	144000	274100	Box
	60	3′5″	13′0″	13′10″	15′0″	162000	175#	144000	295000	Box
	70	3′5″	13′0″	16′6″	16′6″	a86000	175#	144000	351000	Box
	80	3′5″	13′0″	16′6″	16′6″	a89000	175#	144000	375000	Box
	90	3′5″	13′0″	16′6″	16′6″	a92000	175#	144000	408300	Box
	100	3′5″	13′0″	16′6″	16′6″	a96400	175#	144000	459000	Box
	110	3′5″	13′0″	16′6″	16′6″	a100000	175#	144000	504000	Box
	120	3′5″	13′0″	16′6″	16′6″	a105000	175#	144000	547000	Box

a = 16 wheels per crane.
clearances for higher capacities available upon request



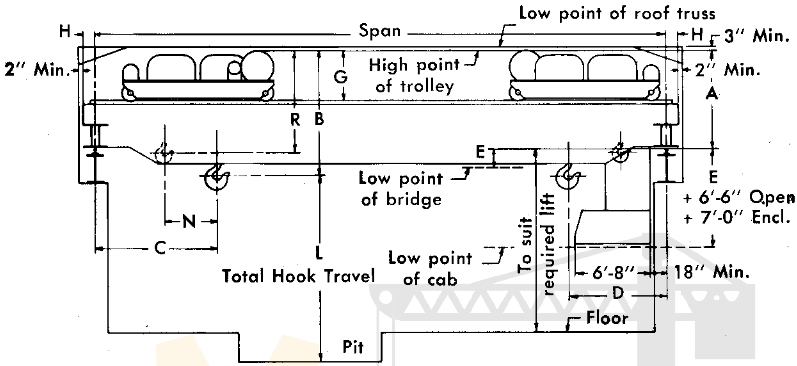
See Notes, Pages 26, 27 and 34

Capacity Tons	Span Ft.	A	B	C	D	E	G	H	J	K	L
100 2 - 50/10 trolleys 7-Motor Add or Deduct 4′2″ lift and 1400# trolleys weight for each 6″ change of "K"	40	8′10″	6′10″	8′0″	8′0″	4″	4′0″	10¼″	12′6″	8′0″	35′10″
	50	9′2″	6′10″	8′0″	8′0″	7″	4′0″	10¼″	12′6″	8′0″	35′10″
	60	9′4″	6′10″	8′0″	8′0″	1′5″	4′0″	11″	12′6″	8′0″	35′10″
	70	9′5″	6′10″	8′0″	8′0″	1′8″	4′0″	11″	12′6″	8′0″	35′10″
	80	9′6″	6′10″	8′0″	8′0″	1′10″	4′0″	9½″	5′0″	10′0″	52′0″
	90	9′7″	6′10″	8′0″	8′0″	2′6″	4′0″	9½″	5′6″	10′0″	52′0″
	100	9′8″	6′10″	8′0″	8′0″	2′11″	4′0″	10¼″	5′6″	10′0″	52′0″
	110	10′0″	6′10″	8′0″	8′0″	3′0″	4′0″	10¼″	5′6″	10′0″	52′0″
	120	10′9″	6′10″	8′0″	8′0″	3′0″	4′0″	10¼″	5′6″	12′0″	69′0″
	NOTE: Minimum Distance Between Main Hooks = 10′3″										
150 2 - 75/15 trolleys 7-Motor Add or Deduct 3′6″ lift and 2500# trolleys weight for each 6″ change of "K"	50	10′3″	7′2″	9′6″	9′6″	1′4″	4′11″	9½″	4′6″	10′0″	38′0″
	60	10′9″	7′2″	9′6″	9′6″	1′6″	4′11″	10¼″	5′0″	10′0″	38′0″
	70	11′0″	7′2″	9′6″	9′6″	1′11″	4′11″	10¼″	5′0″	10′0″	38′0″
	80	11′0″	7′2″	9′6″	9′6″	2′5″	4′11″	10¼″	5′0″	10′0″	38′0″
	90	11′3″	7′2″	9′6″	9′6″	2′7″	4′11″	10¼″	5′0″	10′0″	38′0″
	100	11′6″	7′2″	9′6″	9′6″	2′8″	4′11″	10¼″	5′0″	10′0″	38′0″
	110	11′10″	7′2″	9′6″	9′6″	2′10″	4′11″	10¼″	5′6″	10′0″	38′0″
	120	12′1″	7′2″	9′6″	9′6″	3′0″	4′11″	10¼″	5′6″	12′0″	52′0″
	NOTE: Minimum Distance Between Main Hooks = 10′0″										
200 2 - 100/15 trolleys 7-Motor Add or Deduct 2′9″ lift and 2500# trolleys weight for each 6″ change of "K"	50	11′6″	7′4″	8′2″	8′2″	1′2″	5′0½″	10¼″	5′6″	12′0″	46′6″
	60	11′9″	7′4″	8′2″	8′2″	1′11″	5′0½″	10¼″	5′6″	12′0″	46′6″
	70	11′9″	7′4″	8′2″	8′2″	1′11″	5′0½″	10¼″	5′6″	12′0″	46′6″
	80	12′3″	7′4″	8′2″	8′2″	2′0″	5′0½″	11″	5′6″	12′0″	46′6″
	90	12′6″	7′4″	8′2″	8′2″	2′7″	5′0½″	11″	6′0″	12′0″	46′6″
	100	12′9″	7′4″	8′2″	8′2″	2′2″	5′0½″	11″	6′0″	12′0″	46′6″
	110	13′3″	7′4″	8′2″	8′2″	1′9″	5′0½″	11″	6′0″	12′0″	46′6″
	120	13′3″	7′4″	8′2″	8′2″	1′9″	5′0½″	11″	6′0″	12′0″	46′6″
	NOTE: Minimum Distance Between Main Hooks = 10′4″										



See Notes, Pages 26, 27 and 34

Capacity Tons	Span Ft.	N	R	X	Y	Max. Wheel Load a	Run-way Rail	Trolley Weight Each	Total Crane Wt.	Type of Girder
100 2 - 50/10 trolleys	40	4′11″	7′6″	7′8″	9′3″	108000[4]	175#	31900	114300	Box
	50	4′11″	7′6″	7′8″	9′3″	120300[4]	175#	31900	127000	Box
	60	4′11″	7′6″	7′10″	9′3″	130600[4]	175#	31900	143500	Box
	70	4′11″	7′6″	7′10″	9′3″	138600[4]	175#	31900	158500	Box
	80	4′11″	7′6″	8′10″	10′6″	74000[8]	100#	35000	177000	Box
	90	4′11″	7′6″	9′1″	10′9″	77600[8]	100#	35000	197200	Box
	100	4′11″	7′6″	9′3″	10′9″	81100[8]	100#	35000	221000	Box
	110	4′11″	7′6″	9′3″	10′9″	84400[8]	100#	35000	242000	Box
	120	4′11″	7′6″	10′3″	11′9″	90200[8]	100#	38000	268000	Box
	a = Number of wheels per crane.									
150 2 - 75/15 trolleys	50	5′9″	7′8″	8′7″	10′2″	82000[8]	100#	45400	169000	Box
	60	5′9″	7′8″	8′11″	10′6″	89400[8]	100#	45400	189600	Box
	70	5′9″	7′8″	8′11″	10′6″	95000[8]	135#	45400	206400	Box
	80	5′9″	7′8″	8′11″	10′6″	100300[8]	175#	45400	225200	Box
	90	5′9″	7′8″	8′11″	10′6″	104700[8]	175#	45400	245000	Box
	100	5′9″	7′8″	8′11″	10′6″	109300[8]	175#	45400	264800	Box
	110	5′9″	7′8″	9′2″	10′9″	114100[8]	175#	45400	290700	Box
	120	5′9″	7′8″	10′2″	11′9″	120800[8]	175#	49800	326000	Box
	a = Number of wheels per crane.									
200 2 - 100/15 trolleys	50	4′1″	7′10″	10′1″	11′9″	112700[8]	175#	61050	229700	Box
	60	4′1″	7′10″	10′1″	11′9″	121300[8]	175#	61050	248700	Box
	70	4′1″	7′10″	10′1″	11′9″	128400[8]	175#	61050	265200	Box
	80	4′1″	7′10″	10′3″	11′9″	135100[8]	175#	61050	289000	Box
	90	4′1″	7′10″	10′6″	12′0″	140000[8]	175#	61050	315300	Box
	100	4′1″	7′10″	10′6″	12′0″	146100[8]	175#	61050	341600	Box
	110	4′1″	7′10″	10′9″	12′0″	152000[8]	175#	61050	376900	Box
	120	4′1″	7′10″	10′9″	12′0″	158400[8]	175#	61050	414200	Box
	a = Number of wheels per crane.									



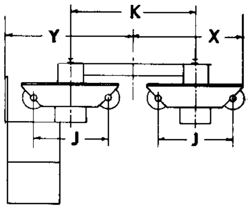
See Notes, Pages 26, 27 and 34

Capacity Tons	Span Ft.	A	B	C	D	E	G	H	J	K	L
250 2 - 125/20 trolleys 7-Motor Add or Deduct 3'6" lift and 2900# trolleys weight for each 6" change of "K"	50	12'3"	7'10"	8'4"	8'4"	8"	5'2"	11"	5'6"	13'0"	43'0"
	60	12'6"	7'10"	8'4"	8'4"	11"	5'2"	11"	5'6"	13'0"	43'0"
	70	12'9"	7'10"	8'4"	8'4"	1'1"	5'2"	11"	5'6"	13'0"	43'0"
	80	13'3"	7'10"	8'4"	8'4"	2'3"	5'2"	11½"	6'0"	13'0"	43'0"
	90	13'6"	7'10"	8'4"	8'4"	2'0"	5'2"	11½"	6'0"	13'0"	43'0"
	100	14'0"	7'10"	8'4"	8'4"	1'4"	5'2"	12"	4'6"b	16'6"	67'0"
	110	14'3"	7'10"	8'4"	8'4"	1'4"	5'2"	12"	4'6"b	16'6"	67'0"
	120	14'6"	7'10"	8'4"	8'4"	1'1"	5'2"	12"	4'6"b	16'6"	67'0"

NOTE: Minimum Distance Between Main Hooks = 11'4"
b - Wheel spacing = 4'6"-3'0"-4'6"-4'6"-4'6"-3'0"-4'6"

Capacity Tons	Span Ft.	A	B	C	D	E	G	H	J	K	L
300 2 - 150/25 trolleys 7-Motor Add or Deduct 2'7" lift and 3500# trolleys 6" change of "K"	60	13'6"	8'6"	8'0"	8'0"	6"	5'8"	12"	4'6"b	16'6"	59'0"
	70	13'9"	8'6"	8'0"	8'0"	6"	5'8"	12"	4'6"b	16'6"	59'0"
	80	14'3"	8'6"	8'0"	8'0"	9"	5'8"	12"	4'6"b	16'6"	59'0"
	90	14'9"	8'6"	8'0"	8'0"	9"	5'8"	12"	4'6"b	16'6"	59'0"
	100	15'0"	8'6"	8'0"	8'0"	12"	5'8"	12"	4'6"b	16'6"	59'0"
	110	15'3"	8'6"	8'0"	8'0"	9"	5'8"	12"	4'6"b	16'6"	59'0"
	120	15'3"	8'6"	8'0"	8'0"	9"	5'8"	12"	4'6"b	16'6"	59'0"

NOTE: Minimum Distance Between Main Hooks = 13'6"
b - Wheel spacing = 4'6"-3'0"-4'6"-4'6"-4'6"-3'0"-4'6"



See Notes, Pages 26, 27 and 34

Capacity Tons	Span Ft.	N	R	X	Y	Max. Wheel Load a	Run-way Rail	Trolley Weight Each	Total Crane Wt.	Type of Girder
250 2 - 125/20 trolleys	50	4′2½″	8′0″	10′10″	12′3″	132500^{8}	175#	63400	243300	Box
	60	4′2½″	8′0″	10′10″	12′3″	142000^{8}	175#	63400	261100	Box
	70	4′2½″	8′0″	10′10″	12′3″	151200^{8}	175#	63400	285500	Box
	80	4′2½″	8′0″	11′3″	12′6″	158800^{8}	175#	63400	316200	Box
	90	4′2½″	8′0″	11′3″	12′6″	165200^{8}	175#	63400	346500	Box
	100	4′2½″	8′0″	15′8″	15′8″	92000^{16}	175#	73400	450300	Box
	110	4′2½″	8′0″	15′8″	15′8″	95700^{16}	175#	73400	496600	Box
	120	4′2½″	8′0″	15′8″	15′8″	99200^{16}	175#	73400	539000	Box

a = Number of wheels per crane.

Capacity Tons	Span Ft.	N	R	X	Y	Max. Wheel Load a	Run-way Rail	Trolley Weight Each	Total Crane Wt.	Type of Girder
300 2 - 150/25 trolleys	60	4′6″	8′11″	15′8″	15′8″	88000^{16}	175#	85000	364000	Box
	70	4′6″	8′11″	15′8″	15′8″	93000^{16}	175#	85000	390000	Box
	80	4′6″	8′11″	15′8″	15′8″	98000^{16}	175#	85000	418000	Box
	90	4′6″	8′11″	15′8″	15′8″	102000^{16}	175#	85000	488100	Box
	100	4′6″	8′11″	15′8″	15′8″	106300^{16}	175#	85000	538000	Box
	110	4′6″	8′11″	15′8″	15′8″	111400^{16}	175#	85000	588000	Box
	120	4′6″	8′11″	15′8″	15′8″	115000^{16}	175#	85000	638800	Box

a = Number of wheels per crane.

SECTION VII — THE CRANE INQUIRY

The use of this section in conjunction with Section VIII enables the prospective purchaser to give the crane builder the necessary facts of operation and clearances which will procure a quotation covering a crane to meet performance requirements at the lowest initial cost and operating expense.

The following information should be included in the request for quotation:

CRANE INFORMATION FORM

1. Type of crane (Sec. II) ....
2. Number cranes required ....
3. Capacity: Main Hoist .... Tons Aux. Hoist .... Tons.
4. Span: Center to center runway rails .... Ft. .... In.
5. Lift of hook(s) (Max. including pits or wells below floor elevation) Main Hoist .... Ft. .... In. Aux. Hoist .... Ft. .... In.
6. Building clearances and runway (Sec. VI & XIV)
   - A. Floor to top runway rail: Ft. .... In. ....
   - B. Top runway rail to lowest overhead obstruction. (Allow for truss sag) .... Ft. .... In.
   - C. Center of runway rail to face of building column or side obstruction. .... Ft. .... In.
   - D. Approximate length of runway: Ft. .... Size of runway rail: ....
   - E. Number of cranes on runway: ...., Type of bumper desired ....
   - F. Location of runway conductors: ....
   - G. Knee braces — underneath clearances, etc. .... If knee braces, pipes, lights, or any other items interfere with crane clearance, enclose sketch. If there are any obstructions underneath the crane which might interfere with the underside of the girder or cab, give complete information.
7. Service Information: (Sec. IV)
   - A. Main Hoist: Service Class .... Number of lifts per hour .... Per day .... Hours per day .... Year .... Hook .... Magnet .... Bucket .... Give size and weight of magnet or bucket ....
   - B. Aux. Hoist: Service Class .... Number of lifts per hour .... Per day .... Hours per day .... Year .... Hook .... Magnet .... Bucket .... Give size and weight of magnet or bucket ....

C. Bridge: Service Class ....
Number moves per hour .... Hours per day .... Year ....
Average Movement .... Ft.

D. Trolley: Service Class ....
Number moves per hour .... Hours per day .... Year ....
Average Movement .... Ft.

8. Furnish complete information regarding special conditions such as acid fumes, steam, high temperatures, high altitudes, excessive dust or moisture, very severe duty, special or fine handling ....
....

9. Ambient temperature in building: Max. .... Min. ....

10. Material handled .... Weight per unit ....

11. Speeds required: Main Hoist .... FPM Bridge .... FPM
Aux. Hoist .... FPM Trolley .... FPM

12. Crane to operate: Indoors .... Outdoors .... Both ....

13. Current: Volts .... Phase .... Cycle .... A.C. Volts .... D.C.

14. Crane control (Sec. IX-C)
Method of control: Cab .... Floor .... Remote .... Radio ....
Type of cab: Open .... Enclosed .... Air-Conditioned ....
Location of control: End of crane .... Center .... On trolley ....
Messenger track on bridge .... Other ....
Type of Control: (Give complete information including preferred manufacturer.)
Drum Radial Lever .... Full Magnetic .... Other ....
Type of Control Enclosure: (Sec. IX-C) ....

15. Crane Motors (Sec. IX-C)
Type of Motors: (Give complete information including preferred manufacturer)
....

16. Crane Wiring
Must wiring comply with Special Conditions or Codes ....
Describe briefly (See Items 8 and 9) ....

17. Preferred bridge conductors. (Sec. IX A) ....

18. Are runway conductors to be included (Sec. XIV) ....
Type: Loose Wires .... Rigid Wires .... Angles .... Other ....

19. List any Special Equipment or Accessories Desired (Sec. XIII) ....
A. Preferred type of lubrication: ....

20. Specify when double hook cranes, double trolley cranes, or special cranes are required giving detailed information on hook spacing, etc. ....

21. Is price to include superintendent of erection? Sec. XV. ....

SECTION VIII – TYPICAL CRANE SPECIFICATIONS

In addition to the data outlined in the previous section, the following general crane specification should be included in a request for quotation to assure the purchaser that all offerings are on an equal basis and to permit the crane builder to correctly interpret the requirements of operation and offer adequate equipment. This specification is not intended to apply to certain manufacturer's products, but is merely a summary of good quality crane design as detailed in Section IX: Part A — Bridge; Part B — Trolley; and Part C — Electrical.

This typical specification not only applies to overhead traveling cranes, but may be adapted to cover all types of cranes shown in Section II.

SAMPLE SPECIFICATION

For Class C Moderate Service Crane (Indoor)

GENERAL

STRESSES: Materials shall be properly selected for the stresses to which they will be subjected. Load carrying parts, except girders and hoisting ropes, shall be designed so that the calculated static stress in the material, based on rated load, shall not exceed 20% of the assumed average ultimate strength of the material. This limitation of stress provides a margin of strength to allow for variations in the properties of materials, manufacturing and operating conditions, and design assumptions, and under no condition should imply authorization or protection for users loading the crane beyond rated capacity.

MATERIAL: All structural steel used shall conform to ASTM-A7, A36 specifications or shall be an accepted type for the purpose for which the steel is to be used and for the operations to be performed on it. Other suitable materials may be used provided parts are proportioned to give comparable design factors.

All iron castings shall be a tough grade gray iron, free from injurious blow holes and cold shuts. Best grade of steel shafting shall be used. All steel castings, bronze, babbitt, and other material not specifically mentioned shall be of strictly first-class quality.

WORKMANSHIP: All apparatus covered by this specification shall be constructed in a thorough and workmanlike manner. Due regard shall be given in the design for safety of operation, accessibility, interchangeability and durability of parts.

ASSEMBLY: Crane shall be assembled, wired completely, and given no-load running tests at manufacturer's plant before shipment.

Wires shall be pulled through conduit and tagged for identification where connections are necessary. Running tests shall be performed with the control which will operate the crane when in service. After testing and before dismantling for shipment, all wiring and mechanical connections shall be match-marked or tagged to insure proper field assembly.

PAINTING: Before shipment, the crane shall be cleaned and painted with the crane manufacturer's standard paint, unless otherwise specified.

LUBRICATION: The crane shall be provided with all necessary lubrication fittings. All gear trains shall be enclosed in oil or grease-tight housings. High speed gearing and bearings to be splash lubricated.

WARRANTY: For a period of one year after shipment, manufacturer shall furnish f.o.b. point of manufacture, any part that shall prove defective as to workmanship or material and is returned f.o.b. point of manufacture. Manufacturer shall not be liable or responsible for any damage caused by defects, nor for work done, material furnished, alterations, or repairs made by others.

BRIDGE

GIRDERS: The girders shall be of the structural beam, or box section type dependent on capacity, span, speeds, duty cycle, etc. If girders are of the box section type, the web plates are to be stiffened with full length diaphragms where required and short diaphragms are to be inserted between the full length diaphragms to transmit the trolley wheel load to the web plates of the girders. The girders shall be of all welded construction.

Except for cranes with equalizing bogie trucks, the girders shall be notched at each end and seat angles shall be welded to the girders to provide a connection to the end trucks by means of turned bolts, fitted in reamed holes. Heavy gussets shall be attached to the bottom of the truck to insure rigidity and squareness.

Girders shall be calculated in accordance with the most recent edition of the Specifications of the Electric Overhead Crane Institute. A rail of adequate size shall be fastened to the top plate of the girder and provided with wheel stops to prevent trolley overrunning.

TRUCKS: Trucks shall be built up from steel plate and shapes to form a rigid section. Ends of the trucks shall be extended to form a mounting for rail sweeps and end stops. The ends of the trucks shall be tied together to prevent spreading. Trucks shall be bored to receive wheel axles or capsule bearings to assure permanent alignment of the crane.

Trucks shall be designed so that each wheel bearing carries an equal share of the load. The wheels shall be rolled steel with taper treads and double flanges and mounted on alloy rotating axles turning on roller bearings.

DRIVE: Bridge shall be driven by a motor located at center of span connected through suitable gearing and cross-shaft to the rotating axles.

An alternate drive consisting of a motor and gear-reducer directly coupled to each driving axle may be offered for long-span bridges and all types of gantry cranes.

BRAKE: The bridge shall be provided with a brake having torque rating equal to 100% of the motor torque and applied by mechanical, hydraulic, pnuematic, electrical or gravity means. Cab-operated cranes shall have a foot-pedal located convenient to the operator.

FOOTWALK: Bridge shall be provided with steel footwalk, running full length of span on the drive girder side. Walk shall be provided with toe-boards on each side and a substantial hand-railing 42" high on its outer edge. Hand rail shall have intermediate rail.

CAB: Cab shall be of the open or enclosed type, made from structural steel and of ample size to accommodate the masters, switches, accessories, and operator. It shall be located in a position to allow maximum travel of the hook and maximum visibility for the operator. It shall be provided with a foot-operated warning signal. A ladder for access to the bridge footwalk shall be furnished.

TROLLEY

FRAME: Framework supporting the hoisting mechanism and trolley travel mechanisms shall be structural steel. It shall be of rigid construction designed to transmit the load to the bridge rails, without undue deflection.

HOISTING ROPES: The ropes shall be of proper design and construction for crane service. The rated capacity load divided by the number of parts of rope shall not exceed 20% of the published breaking strength of the rope.

HOISTING MECHANISM: The hoisting machinery shall consist of an electric motor driving through necessary gear reductions to a winding drum. Gears in the reduction units shall be mounted on short shafts and all gears shall be supported between bearings. Drum gears shall be pressed on and keyed or pinned to the winding drum. All high speed gears shall be enclosed in substantial oil-tight housings, slow speed reduction at the drum shall be suitably guarded. The hoist motor shall be connected to its reducer by means of a flexible coupling.

The diameter of the winding drum(s) shall not be less than 24 times the diameter of the hoisting rope when using 6 x 37 wire rope (or 30 times when using 6 x 19 wire rope). The rope drum(s) shall be grooved right and left hand to receive the full lift of hoisting rope without overlapping.

Rope drum shall be cast iron or fabricated steel and be properly machined for the rope used. Drum shall be of sufficient size and length so at least two turns of rope remain on the drum when hook is in low position.

All sheaves, except idler sheave, shall be at least 24 times the diameter of the rope used. The idler sheave shall be at least 12 times the diameter of the rope used.

LOAD BLOCK: The load block frames shall be of steel construction. The hook shall be of forged steel, supported on a ball or roller thrust bearing. The hook shall rotate freely on this bearing.

BRAKES: Each hoisting unit shall be equipped with two brakes; one self-setting brake (holding brake) applied directly to the motor shaft or some part of the gear train; the other, a mechanical brake or electrical braking (control braking means) shall control the speed during lowering to prevent over-speeding.

The holding brake shall have a torque rating equal to the full-load torque of the hoist motor.

The control braking means shall have sufficient capacity to control the safe lowering speed of the load without overheating while handling the duty cycle of operation.

TROLLEY TRAVEL MECHANISM: Trolley travel mechanism shall consist of motor and gear drive unit connected to double flanged drive wheels. Wheels shall be of high-carbon forged or rolled steel, mounted on axles turning on roller bearings.

ELECTRICAL

MOTORS: Motors shall be of the open (enclosed) type, specifically designed for crane service, of the wound rotor, slip ring design, and of such size that they will run continuously for thirty minutes with a temperature rise not to exceed 70°C for open type and 75°C for enclosed type. Motors to be equipped with anti-friction bearings and required shaft extensions.

CONTROLLERS: Controllers shall be the magnetic type, with sufficient operating speeds to obtain smooth acceleration and accurate control. The resistors shall be specially designed for crane service and shall have a thermal capacity of not less than Class 150 series.

SWITCHBOARD: A main line externally operated isolating switch shall be furnished. This shall open all main conductors and have provision for locking in the open position. This can be furnished as a separate switch or as part of the crane protective panel.

Undervoltage and overload protection shall be provided for each motor either as a function of each controller or by an enclosed protective panel.

HOIST LIMIT SWITCH: The hoist limit switch shall limit the upward travel of the hoist block by removing power from the motor and applying the brake. The limit switch shall be either power circuit or control circuit type.

Interruption of the hoist motion shall not interfere with the lowering motion. Lowering of the block shall automatically reset the limit switch.

WIRING: Crane shall be completely wired before shipment, using bare copper wire for current conductors. All wiring shall be of the stranded type of sufficient size to safely carry the load; it shall be completely enclosed either in conduit or raceways. (Specify local codes to be met, if any.)

All insulated wire, conduit, and fittings shall conform to the requirements of the National Board of Fire Underwriters.

OUT-DOOR CRANES: All cranes for outdoor service shall have electrical equipment and other machinery suitably protected from the weather. An enclosed operator's cab shall be provided.

After a thorough study of the next Section of the Handbook, the reader will be acquainted with quality crane design and will be in a position to use the comparison chart in Section X to evaluate the proposals offered by the crane builders and to select a manufacturer who has offered a design that meets the foregoing typical specifications and inquiry data.

SECTION IX — CRANE DESIGN

The purpose of this section is to give basic engineering information and design formulae that have been applied in the design of cranes. The experience of 69 years of successful crane building is included in the text to aid in the evaluation of crane construction as outlined in the Crane Comparison tables of Section X.

As it would increase manufacturing costs to have a different design of hoist, trolley and bridge drive for each class of service, the crane builder has as few designs and sizes as possible and must use them in the various classes of service by varying the factor of safety and life expectancy. This use of standard parts enables the manufacturer to offer the highest quality crane for the proposed service at the lowest initial cost. Operating economies and availability of replacement parts are further benefits to the purchaser.

In addition to the discussion of general components, this section is divided into the 3 major parts of a crane: A-Bridge; B-Trolley; C-Electrical. For words and phrases peculiar to crane design, refer to Section III, Crane Terminology.

GENERAL CONSIDERATIONS

In order to avoid repetition in the divisions of the Section, the topics and components that are common to the Bridge and Trolley will be discussed under this heading. These are: factor of safety, allowable stress, materials, bearings, gearing, couplings and lubrication.

FACTOR OF SAFETY: The term "factor of safety" is often used in crane specifications. A crane "designed with a factor of safety of 5" has a ratio of 5 to 1 between the ultimate strength of the material and the allowable stresses to which the various crane parts are designed. The term, factor of safety, is misleading in that it implies a greater degree of safety than actually exists. For example, a factor of 5 does not mean that a machine or structure can carry a load five times as great as that for which it was designed. Even though each part of a machine is designed with the same factor of safety, the machine as a whole does not have that same factor of safety. If one part is stressed beyond the proportional limit, or particularly the yield point, the load distribution may be completely changed throughout the entire machine or structure, and its ability to function may thus be changed, though no part has failed.

In an effort to contribute to safe operation of cranes, crane hooks may be purposely designed with a factor of safety of less than five so that, if the crane should ever be severely overloaded, the hook will give visible evidence of overloading by slowly opening at the throat. This action should warn those using the crane that an overload condition exists and further lifting of that load should be stopped to prevent a possible sudden failure of some other obscure but vital part.

The following minimum factors of safety should be specified for the various classes of service. Class A:4; Classes B & C:5; Class D:5; Class E:5 with long-life factor; Class F:5 to 8 with long-life factor.

ALLOWABLE STRESS: Allowable stress is that maximum or limiting stress to which the various crane parts are designed. The allowable stress is otained by dividing the ultimate strength of selected material by the factor of safety. Under certain conditions of loading the allowable stress must be reduced below that which would be given by dividing the ultimate by the factor of safety. The use of wide flange beams on long spans is an example where reduced allowable stresses are necessary.

MATERIALS IN CRANE CONSTRUCTION: In crane design particular attention must be given to the dead weight of the crane. Effective use of material will make a lighter trolley. The trolley weight influences the bridge weight and the total weight of crane will determine the size of runway girders, brackets, columns and foundations.

The principal material used in crane construction is structural carbon steel usually made to the ASTM specification A-7 or A-36. This material is used in the trolley frame and the entire bridge structure.

Striving for a reduction in weight, high alloy steels are now being used wherever design conditions permit. Alloys are also used where cranes are subjected to severe service. In these cranes, tool steel is used for gearing, wheels and in some cases, hoist drums.

The use of cast iron is limited to sheaves, drums, collectors, gear cases, and other parts of a non-structural nature. Drums of steel fabricated design are rapidly gaining favor and replacing cast iron where service conditions are rather severe.

Steel castings may be used for drums, drive case housings and bearing supports. In many instances castings have been replaced with welded structural sections.

Bronze is used in mechanical load brake discs, collector shoes or wheels and thrust plugs. Anti-friction bearings have replaced bronze bushings and bearings in most crane applications.

Although aluminum would permit a reduction in dead weight of a crane, its use is limited because of cost and deflection. Some bridges have been fabricated with this material and its further use is under study.

BEARINGS: The use of anti-friction bearings has contributed much towards improving crane quality. Better service life, less maintenance and inspection, less frequent lubrication, more accurate, permanent alignment of vital parts and smaller horsepower motors are some of the advantages attributed to the use of ball and roller bearings.

The type of bearing shall be as specified by the crane manufacturer.

Anti-friction bearings shall be selected to give a minimum life expectancy based on full rated speed as follows:

	B-10 Life	B-50 (Average) Life
Classes A & B	1,000 hours	5,000 hours
Class C	2,000 hours	10,000 hours
Class D	5,000 hours	25,000 hours
Class E	10,000 hours or 10 years for the service specified, whichever is greater.	50,000 hours or 50 years for the service specified, whichever is greater.

For typical applications, bearing loads for life computation purposes may be assumed equal to 75% of maximum for bridge bearings and 65% of maximum for trolley and hoist bearings.

Bronze Sleeve Bearings: Bronze sleeve bearings, other than track wheel bearings, shall have an allowable unit bearing pressure of 1000 p.s.i. of projected area.

Bronze sleeve bearings for track wheel axle application shall not exceed the following values:

Class A & B — 1200 p.s.i. of projected area
Class C — 1050 p.s.i. of projected area
Class D — 900 p.s.i. of projected area
Class E — 750 p.s.i. of projected area

All bearings shall be provided with proper lubrication or means of lubrication. Bearing enclosures will be designed as far as practicable to exclude dirt and prevent leakage of oil or grease.

Class E and F cranes should be equipped with antifriction bearings of extra capacity for long life. A typical specification for bearings on such cranes might request "10,000 hour minimum life bearings." Minimum life means that 90% of the bearings should be serviceable after the specified hours of life or in the above example .9 of the bearings should endure 10,000 hours life. Average life with its 50% failure is 5 times as long as minmum life with its 10% failure.

A 10-ton, 60′-0″ span Class D service crane equipped throughout with anti-friction bearings and used 2 shifts per day will show a saving of $225.00 per year in cost of power alone when compared to the power cost of a crane equipped with sleeve bearings.

GEARING: Gearing is a vital part of overhead traveling cranes. Recognizing this fact, quality cranes must be designed with particular emphasis on the proper gearing, using the least number of gears and pinions to accomplish the needed reduction.

Herringbone gears, noted for their long life, (3 to 1 over spur) smooth and quiet operation, are particularly desirable, as the gearing to be used in the first reduction in bridge and trolley drives and in both reductions of the hoist case. Because of the inherent advantages of herringbone gears only two gear reductions are required in the hoist case of cranes through 30 ton capacity. For 40 ton capacity and above, a third reduction of spur gearing is usually required to provide the slower hoist speeds common to the higher capacity cranes. This spur reduction, however, is on the output or drum end of the reduction and rotates at such slow speed that no appreciable benefit would be gained by using herringbone gears. Herringbone gears are used only in the first reduction of the bridge and trolley drive cases because provisions for possible end float should be made in the second reduction.

The tooth forms used in crane gearing are the 20° stub tooth for herringbone and heavy duty spur gearing; the 20° full depth tooth for light or moderate loading conditions. The 20° tooth form is replacing the 14½° form largely due to the increased strength obtainable for equal face widths.

The efficiency of crane gearing is figured at .985 for each herringbone reduction and .97 for each spur gear reduction when running in an oil bath in an enclosed case.

COUPLINGS: Flexible couplings of the pin or gear type are recommended for connecting the motor to the gear drive when they are direct-coupled, that is, with no spacer or cross shafting between them. This application should be used on hoist, trolley, and single bridge drives.

Solid couplings of the flange type with halves connected by turned and fitted bolts are used for the high speed cross-shafts of double bridge drives and the slow speed cross-shafts of the trolley and bridge.

LUBRICATION: In crane design, consideration must be given to the accessibility of all moving parts and their proper lubrication to provide reliable operation and adequate service life. A possitive oil bath lubrication should be provided for the hoist, bridge and trolley gear cases and their integral bearings. If an extra reduction is used in the hoist gearing a suitable case should be provided with access so that open gearing grease can be readily applied by brush or swab.

The wheel bearings, cross-shaft bearings, sheave and drum bearings must be provided with fittings for grease lubrication. If these bearings are not accessible from a safe position, tubing or piping should extend the grease fittings from the bearings to accessible locations. Centralized lubrication systems are available for cranes in Classes E and F. These systems cut down the time required for lubrication and add to the safety of personnel by eliminating much of the climbing on the crane.

PART A — BRIDGE DESIGN

This part of the Crane Design Section will be devoted to the components that make up a crane bridge, namely girders, girder end connections, rails, trolley stops, trucks, bumpers, drives, brake, walks, railings, conductors, collectors, control platforms and cabs.

TYPES OF CRANE GIRDERS: Besides the obvious variation of span and capacity, crane girders of various design are in common use. The most frequently used designs are the following: wide-flange beams, capped structural beams, box girders and latticed girders.

Wide-flange beams are an economical choice for crane girders of all capacities with comparatively short spans. As span or capacity requirements increase, the efficiency with which wide-flange girders can be utilized, decreases. Wide-flange beams are limited to 36″ depth. As spans exceed 50 feet, efficient utilization of girder flanges dictates that girder depth exceed this amount. Besides this basic limitation, the allowable stress for wide-flange beams decreases as span increases.

I-beam girders may be wide flange beams, standard I-beams, or beams reinforced with plate, angles, or channels. An auxiliary girder or other suitable means shall be provided to support over-hanging loads to prevent undue torsional and lateral deflections.

The maximum vertical deflection of the girder produced by the dead load, the weight of the trolley and the rated load shall not exceed .00125″ per inch of span. Impact shall not be considered in determining deflection.

The maximum fibre stresses with combined loading shall not exceed:

Tension (net section) — 16000 p.s.i.

Compression: $\frac{12,000,000}{\frac{1d}{bt}}$ with maximum of 16000 p.s.i.

Where:

1 = Span in inches
b = Width of compression flange in inches
t = Thickness of compression flange in inches
d = Depth of beam in inches

Shear — 12000 p.s.i. maximum

The judgment of the crane manufacturer should be followed as to the use of wide-flange beam girders in a particular crane design. Figure 1 shows a typical wide-flange beam crane girder. The characteristics of wide-flange beams used as girders can be improved by plate-connecting the flanges. Figure 2 shows a wide-flange beam of this design.

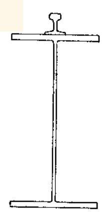


Fig. 1

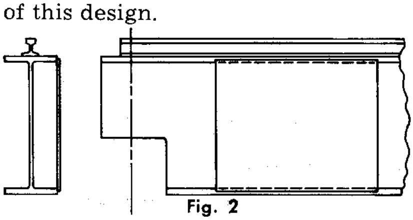


Fig. 2

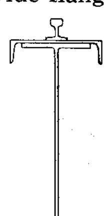


Fig. 3

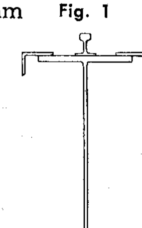


Fig. 4

Capping may extend the useful span or capacity of wide-flange beams used as crane girders. This capping, usually channels, Figure 3 or angles, Figure 4, increases the lateral stiffness as well as the moments of inertia and the section moduli in compression. Capping should be used only in special instances where a wide-flange beam does not quite meet the requirements of width of flange or compression, or a welded box girder would be less economical.

For electric cranes, the beam girders require the addition of an auxiliary channel for spans to 40′-0″ and an auxiliary latticed girder for spans over 40′-0″ to support the bridge walk and drive machinery.

A box girder is the most popular girder design used in overhead traveling cranes because of its design efficiency. Wide-flange beams find their greatest use in building construction where girders are fixed rather than moving and loads are usually distributed over short spans; crane girders move, and carry moving, highly concentrated loads, usually over long spans. Box girders are easily adapted to the conditions encountered in crane design because it is possible to select cover plate width, web depth, stiffener arrangement and material thickness to meet the exact requirements of each crane installation.

Within the box girder classification there are two basic designs: riveted girders, Figure 5, and welded girders, Figure 6. The crane builder can supply either of these types although the riveted crane girder is practically obsolete and only furnished upon request. Riveted box girders weigh more than welded box girders of comparable strength and rigidity. They also require maintenance to make sure that the rivets remain tight.

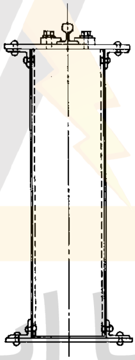


Fig. 5


Fig. 6

The design of welded box girders for commonly used spans and capacities is well standardized, using the most efficient arrangement of web and cover plate sizes to combine high strength with light weight. Many manufacturers now weld the webs to cover plate on automatic welding machines under closely controlled conditions to secure uniform quality welds. Full depth stiffeners and additional partial depth stiffeners welded to webs and bearing on cover plates contribute to the internal strength of these girders. Typical views of welded box girders are shown in Figures 7, 8, 9 and 10.

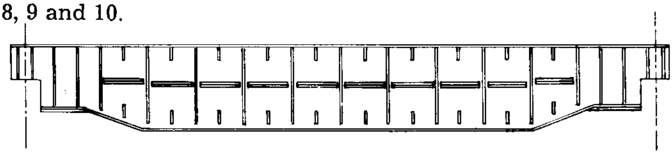


Fig. 7. Longitudinal section, showing arrangement of diaphragms.

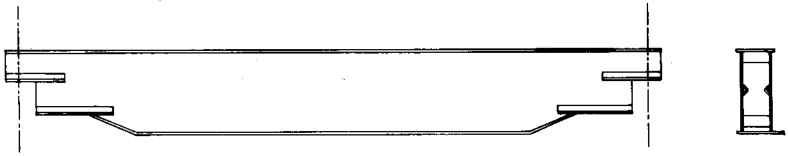


Fig. 8. The completed welded box girder.

Fig. 9. Welded girder, one ready for cover plate, other in process.

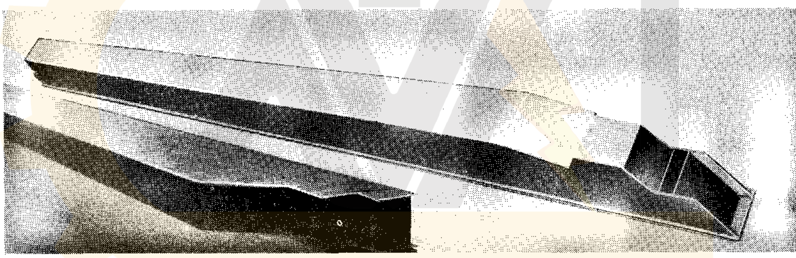


Fig. 10. Girder tilted for welding.

Another type of crane girder design is the latticed girder. This type is recommended for long spans greater than 125'-0", for cranes requiring a minimum of weight to accommodate a runway condition regardless of initial cost, and for outdoor cranes in high wind areas. A girder design suitable for long span would necessarily be very deep, the top and bottom flanges should be far apart. In latticed girder construction the top and bottom flanges can be spaced far apart with much less weight than if solid web plates were used. The big advantage therefore in latticed girder construction is that a large part of the girder weight is distributed where it is most effective and dead load is kept to a minimum. This in turn keeps the bridge wheel loads down and permits a smaller bridge motor and drive as well as a lighter runway construction. It can readily be seen that a latticed girder offers much less wind resistance than a girder of solid web construction and therefore, has less lateral loading and requires less horsepower for bridge travel. A style of latticed girder construction is shown in figure 11.

Fig. 11

Even though latticed girders are basically a very efficient design, their use is restricted to cranes as described, because latticed girders cost more to manufacture than welded box girders and the advantages they possess over box girders of long span would not hold true on short span cranes.

GIRDER COMPUTATIONS: Loadings

1. Crane girders shall be proportioned to resist all vertical, lateral and torsional forces combined as specified in Paragraph #2 page 58 and defined as follows:

a. Vertical forces

(1) Dead Load: The weight of all effective parts of the bridge structure, the machinery parts, and the fixed equipment supported by the structure.

To compute the dead load moment, the weight per foot of the following should be known: girder, bridge rail, walk, railing and cross-shaft. A tentative girder selection must be made. For an economical section, the girder depth should be not less than 1/18 of the span.

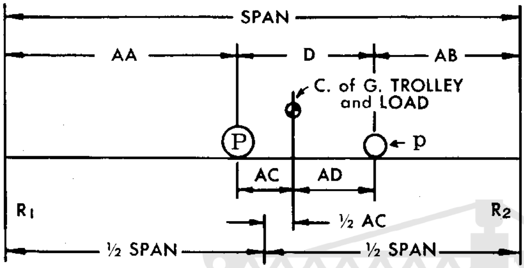
Dead load moment — Wt. Per Foot of above Items x Span in Ft.^{2} x 1.5 = ...

Moment due to bridge motor and drive case = weight of motor & drive case x span in ft. x 3 = ...

NOTE: For cabs located at the center of the span add cab weight to bridge motor and drive in computing moment (3) above. For cabs located at end of girder, moment due to cab need not be computed.

(2) Live Load: The weight of the trolley and the lifted load (rated capacity) shall be considered as concentrated moving loads at the wheels and located in such positions as to produce the maximum moment and shear.

Live load bending moment can be computed as follows:



Position of single trolley on bridge to obtain maximum moment.
P and p — Trolley Wheel Loads — P being the larger.
D — Wheelbase of Trolley.
AC and AD — Distances from trolley wheels to center of gravity of trolley.
AA — Distance from left end of span to wheel P.
AB — Distance from right end of span to wheel p.
R_1 - R_2 — Left and right girder reactions.

$$R_1 = \frac{AB + D}{Span} \times P + \frac{AB}{Span} \times p = \dots\dots$$

Live load moment $= R_1 \times AA = \dots\dots$

or

$$\text{Live load moment} = \frac{(P + p)}{41}\left(1 - \frac{p}{p + P}\, D\right)^2 = \dots\dots$$

(3) Impact Allowance: For cranes in Classes A, B, C and D, the minimum impact allowance shall be 15% of the rated capacity. For Class E, the impact allowance shall be 50% of the total load. Total load, for this purpose, is defined as the combined weight of the bucket, magnet or grapple, plus its load.

b. Lateral Forces

(1) Lateral load due to acceleration or deceleration shall be considered as 5% of the live load plus the crane bridge, exclusive of end trucks and end ties. The live load shall be considered as a concentrated load, located in the same position as when calculating the vertical moment. The lateral moment shall be equally divided between the two girders and the moment of inertia of the entire girder section about its vertical axis shall be used to determine the stresses due to the lateral forces.

(2) Lateral load due to wind shall be considered as 30 pounds per square foot of projected area. The wind load on the trolley shall be considered as equally divided between the two girders.

c. Torsional Forces

(1) The twisting moment due to starting and stopping of the bridge motor shall be considered as the starting torque of the bridge motor at 200% of full load torque multiplied by the gear ratio between the motor and the cross shaft.

(2) The twisting moments due to overhanging loads on the side of the girder shall be taken as their respective weights multiplied by the horizontal distances between the respective centers of gravity and the center of gravity of the girder section.

(3) The twisting moments due to lateral forces acting eccentric to the horizontal neutral axis of the girder shall be considered as those forces multiplied by the vertical distance between the center line of force and the center of gravity of the girder.

2. The combined bending stress shall be taken as the larger of:

a. The sum of the maximum stresses due to a(1) dead load, a(2) weight of trolley, rated load and a(3) impact allowance.

b. The sum of the maximum stresses due to a(1) dead load, a(2) weight of trolley, rated load and b(1) b(2) lateral forces.

3. The combined shear stress shall be taken as the sum of the maximum shears due to dead load, weight of trolley, rated load, impact allowance and c(1) (2)(3) net twisting moment.

4. For other conditions of loading see AISC Handbook, formulae for bending moments.

GIRDER COMPUTATIONS: Design Limitations

Welded box girders shall be fabricated of structural steel with continuous longitudinal welds running the full length of the girder. All welds shall be ample to develop the beam section for the maximum shear and bending. Weld stresses shall not exceed 20% of the average ultimate strength of the weld material.

a. Proportions

1/b shall not exceed 55

b/c shall not exceed 60

h/t shall not exceed 240 or the amount, whichever is smaller, given by the formula:

$$85\ (k + 1)\ \sqrt{\frac{16000}{f_c}}$$

unless longitudinal stiffeners are used in the compression area of the web plates.

Where: 1 = Span in inches

b = Distance between web plates in inches

c = Thickness of top cover plate in inches

f_c = Maximum compressive stress (p.s.i.)

f_t = Maximum tensile stress (p.s.i.)

h = Depth of web in inches
k = f_t/f_c
t = Thickness of web in inches

b. Maximum Allowable Combined Stresses
Tension = 16,000 p.s.i.
Compression = 16,000 p.s.i. or when b/c exceeds 41 the compressive stress in the top flange shall be reduced as follows:

b/c = 43: f_c = 15000	b/c = 52: f_c = 10000
b/c = 46: f_c = 13000	b/c = 55: f_c = 9000
b/c = 50: f_c = 11000	b/c = 60: f_c = 7000

Shear — The maximum unit shear on the area of the web plates shall not exceed 12,000 p.s.i.

c. Diaphragms and Vertical Stiffeners
The spacing of the vertical web stiffeners in inches shall not exceed the amount given by the formula:

$$\frac{11{,}000t}{\sqrt{v}}$$

Where: t = Thickness of web in inches
v = Shear stress in web plates (p.s.i.)

Full depth diaphragms may be included as vertical web stiffeners toward meeting this requirement.

The distance between full depth diaphragms shall not exceed 72″ except for girders with web depths greater than 72″ when the distance between full depth diaghragms may be a maximum equal to the web depth.

Web plates shall be suitably reinforced with full depth diaphragms or stiffeners at all major load points.

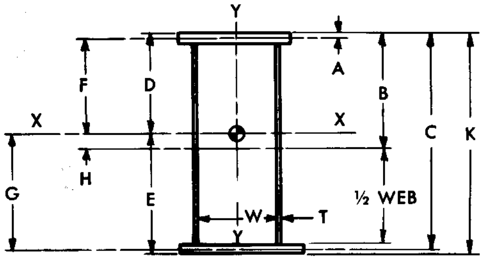
All diaphragms shall bear against the top cover plate and shall be welded to the web plates. The diaphragm section and weld shall be adequate to transfer the maximum trolley wheel load to the web plates.

Short diaphragms shall be placed between full depth diaphragms so that the maximum distance between adjacent diaphragms will not exceed

$$\frac{108{,}000\ S}{W}$$

Where: S = Section modulus of bridge rail in inches^3
W = Maximum trolley wheel load in pounds, excluding impact

Properties of the section, Neutral Axis, Vertical Moment of Inertia and Section Modulus tentatively chosen for the girder can be obtained by filling in the following form:



$$D = \frac{\text{Moment}}{\text{Area}}$$

$$E = K - D$$

$$Sc = \frac{\text{Total I}}{D}$$

$$St = \frac{\text{Total I}}{E}$$

Part	Area	x Dist.	Moment	C.G. to N.A.	Dist.^{2}	x Area	I ea. part	
Top Plate		x A		F	F^2			
Web "		x B		H	H^2			
Bott. "		x C		G	G^2			
Total	Area		Moment					Total I

The horizontal properties for the computation of lateral stresses may be obtained in the same manner using areas about axis Y-Y.

COMPUTATIONS OF STRESSES: After obtaining Sc and St, the section modulus in compression and tension, the girder stress can be computed by dividing the total bending moment by Sc to obtain the compressive stress and by St to obtain tensile stress. The same procedure shall be followed for the horizontal stresses where required. Girder stress computations are made on a per girder basis.

Other computations are made to determine various details, such as spacing and depth of stiffeners and rail supports, of the girder structure. The basic computation of the bending moment and bending stresses establishes the girder shape and size of members.

DEFLECTION: In addition to strength requirements it is also important to check the vertical deflection of the girder as this may determine the girder design, in many instances, over the strength formula. If deflection is above the limitations given, the girder will be "limber" and the vertical positioning of the load will become a tedious and time-consuming operation. Excessive deflection also permits the trolley to drift out of the desired location to the low point of the deflecting girder.

The deflection is figured by the following formulae:

Live load deflection $= \frac{W_1\ l^3}{48EI}$ (1)

Uniform dead load deflection $= \frac{W_2\ l^3}{77EI}$ (2)

Concentrated dead load at center deflection $= \frac{W_3\ l^3}{48EI}$ (3)

W_1 = one-half of rated load plus one-half trolley weight in pounds.
W_2 = weight in pounds of girder, rail, walk, railing and cross shaft.
W_3 = Weight in pounds of motor, drive, and crane cab (if located at or near center of span).
l = span in inches.
E = Modulus of elasticity = 30,000,000 for steel.
I = Moment of Inertia of the girder about the horizontal axis.

Total deflection is the sum of (1), (2), and (3) and shall not exceed .015 inch per foot of span for Classes A, B and C and not exceed .0125 inch per foot of span for Classes D and E.

Impact shall not be considered in determining deflection.

Crane girders should have a camber (crown) at center equal to the sum of one-half (1) plus all of (2) and all of (3).

GIRDER END CONNECTIONS: The method of attaching the bridge girders to the trucks is very important because upon this depends the rigidity of the crane to prevent skew in operation. Figures 12 and 13 show proven connections. Girder loads enter the truck structure as direct bearing loads thru the stiffener plates and shelf angles. An additional means of holding the girder square with the truck is provided by the large gusset plate welded to the bottom of the truck and attached to the girders with turned bolts. It is also imperative that a substantial end girder connection as shown in Figure 14 be provided to give fixed end support to the girders in computing lateral stresses.

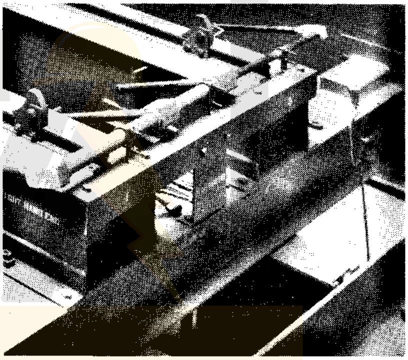


Fig. 12

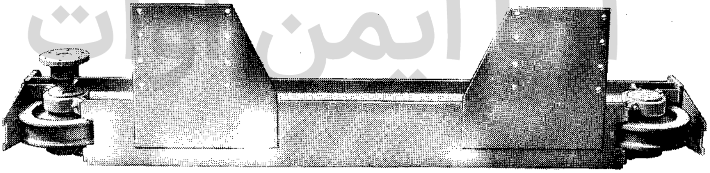


Fig. 13

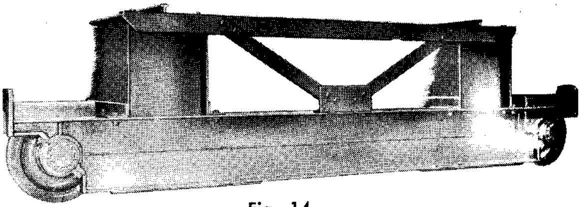


Fig. 14

On those crane installations where overhead clearances prohibit the use of standard crane construction cranes of "dropped girder" construction are sometimes used. This construction allows the top of the girder to be positioned as required to provide necesary overhead clearance.

BRIDGE RAILS: The choice of bridge rails is correlated to the selection of trolley wheels. See computations and tables under bridge wheels for recommended size of rails. Aside from the wheel diameter and rail width consideration, rail selection is also influenced by the manner in which the rail is supported on the crane girder.

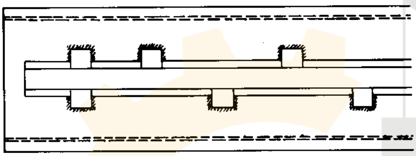


Fig. 15

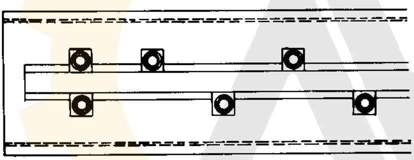


Fig. 16

Ordinarily bridge rails are attached to the bridge girders by means of alternately spaced rail clips that can be welded or attached with bolts or cap screws. See Figure 15 and 16. The welding of clips is preferred. There should be no need for future realignment of bridge rails which is in contrast to the mounting of runway rails that may need occasional realignment. For rail dimensions see Section XIV.

On cranes over 30 tons capacity it is recommended that the bridge rails be of sufficient size to safely carry the trolley wheel load between bars placed above each girder stiffener so that the bending stress produced by the trolley wheel load between stiffeners is not transmitted into the top cover plate thereby adding stresses to those previously found in the preceding girder computations. See Figure 17 for this design.

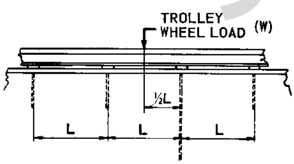


Fig. 17

$$\text{Maximum Bending Moment} = \frac{W \times L}{6}$$

$$\text{Stress} = \frac{W \times L}{6 \times S.M.} = 18000\# \text{ per sq. inch maximum}$$

W = Maximum trolley wheel load.
L = Center to center of stiffeners in inches.
S.M. = Section Modulus of bridge rail.

TROLLEY STOPS: Typical trolley stops are shown in Figures 18, 19, 20 and 21. Figures 18 and 19 show types of stops that engage the trolley wheel rather than some part of the trolley frame. The stop shown in figure 20 is of preferred design because impact loads caused by hitting the stops do not put shock loading on the trolley wheel bearings. These stops must be of substantial construction and so located that they will permit the maximum travel of the trolley across the bridge.

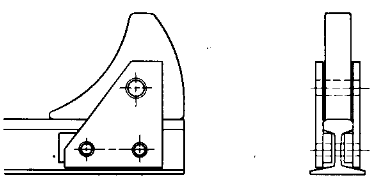


Fig. 18

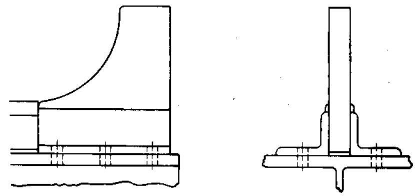


Fig. 19

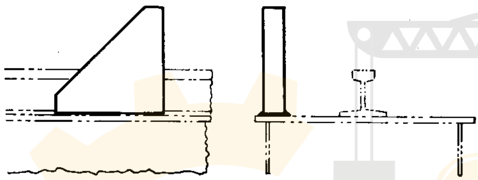


Fig. 20

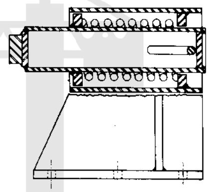


Fig 21

TROLLEY BUMPERS: Trolleys with travel speeds in excess of 175 FPM should be equipped with bumpers, mounted on the bridge girders as shown in Figure 21 or of the double-acting type mounted on the sides of the trolley and engaging bumping blocks on the bridge. These bumpers should follow the specification for bumpers in Section XIV, page 186 except that the speed shall be considered at ⅓ full load speed and the rate of deceleration not to exceed 4.7 ft. per sec. per sec.

BRIDGE TRUCKS: The design of structural, bearings and axles of bridge trucks is primarily determined by the maximum wheel load. This load is computed by adding the following:

(1) ½ weight of trolley and rated load positioned on bridge with its hook at the nearest approach to the runway rail.

(2) ¼ weight of girders, rails and trucks.

(3) ½ weight of bridge motor, drive, cross-shaft, bearings, walk, railing or auxiliary girder and all supports.

(4) weight of cab and control if at end of bridge; Proportion weight according to position if not at end.

Divide the sum of 1, 2, 3 and 4 by the number of wheels at cab end of drive girder (one for four-wheel crane, two for bogie trucks) to arrive at the maximum load per wheel, hereafter designated as maximum wheel load.

The longitudinal force in the bridge produced by the movement of the trolley shall be taken as 10% of the weight of trolley and load on each truck.

The horizontal force produced by the movement of the bridge on the runway shall be 20% of the maximum load per wheel for 2-

wheel trucks and 40% for 4-wheel trucks.

TYPES OF TRUCKS: The design of bridge trucks is influenced by wheel loading and the service conditions under which the crane will be used. Where conditions warrant, 2-wheel standard trucks such as shown in Fig. 14, page 61, and Fig. 22 are ordinarily used for all classes of service. On larger capacity cranes with maximum wheel loads exceeding 170,000#, and standard runway construction, it becomes necessary to use 2-wheel trucks with short wheel base at the end of each girder. Figures 23 and 24 show 2-wheel, bogie end-trucks of both the solid-connected (fixed) and pin-connected (equalizing) types. If the runway is substantial and service conditions, Classes A, B and C, are not severe the fixed type of 2-wheel end truck may be used. The equalizing type of bogie truck is preferred for heavy duty, fast cranes, Classes D, E, F, or where the runway might become uneven. As cranes increase beyond the capacity of the two 2-wheel trucks, it becomes necessary to use four 2-wheel trucks, Figure 25, at each end. Eight-wheel bogie construction is always of the equalizing type, because it would be quite impossible to equalize the wheel loads of so many wheels without a flexible or pin connection.

Fig. 22

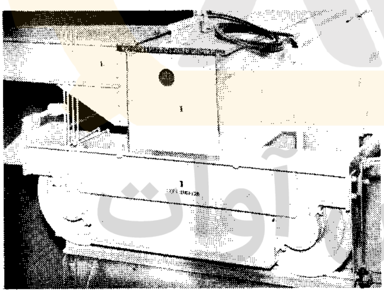


Fig. 23

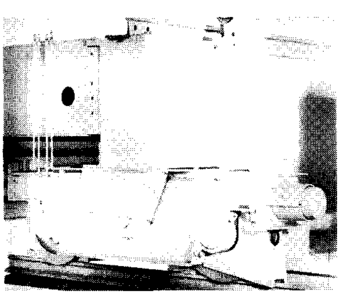


Fig. 24

STRUCTURAL TRUCKS: Bridge trucks of the standard 2-wheel type are fabricated from wide flange beams or channels and cover plates. Class A and B cranes may be designed with single channel trucks, Figure 26. The bending moment is computed by multiplying the maximum wheel load by the distance in inches from the center of axle to the centerline of bridge girder. Stresses must be kept under 13,000 PSI to avoid excessive deflection. The wheelbase for Class A cranes may be 1/8 of the span; Classes B, C, D and E must be at least 1/7 of the span and Class F usually requires 1/6 of the span.

Girders are connected to these trucks with large gusset plates and fitted bolts in such a manner that the entire bridge structure becomes a rectangle that will not weave or twist.

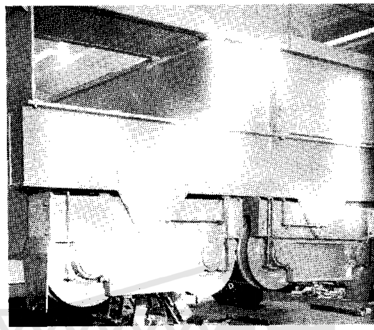


Fig. 25

On cranes with 4 or more wheels on each end, the preferred truck construction consists of plates forming a welded box section. The wheel base for the crane is determined by the distance between centers of the extreme or outside wheels. These cranes must have substantial connections at the top and between the girders to hold the girders and end girder connection in a rigid rectangular shape.

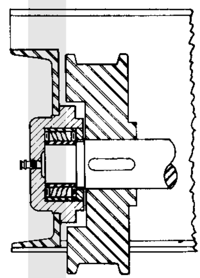


Fig. 26

AXLES and BEARINGS: The crane bridge axles in common use are either of the fixed axle, Figure 27, or rotating axle, Figure 28, types. The fixed axle, or pin and keeper, type was used extensively in the past. In most cases fixed axle design is now limited to handpower cranes, or electric cranes used only for intermittent service. Although the fixed axle design is an economical one there are disadvantages. In this design the torque required to turn the drive wheels must be transmitted directly to the wheel by means of a gear attached to, or a part of the wheel. This necessitates gearing at the truck which is difficult to conveniently enclose and in many instances it is left as open gearing. These wheels may be fitted with either bronze bushings or roller bearings.

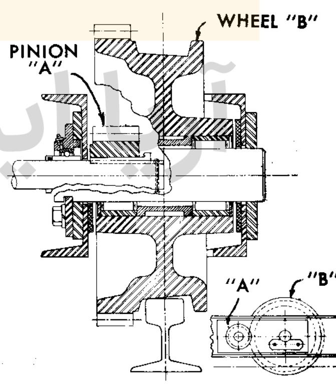


Fig. 27

The rotating axle mounted on roller bearings in bearing capsules is the accepted design today. In this design the axle is driven directly from the cross-shaft. This allows the designer to locate the drive gearing anywhere he chooses along the cross-shaft, which can be considered as an extension of, or connection between axles on opposite ends of a crane. It also assures an equal loading on each bearing with the wheel directly between them. Bearing life and capacity has been considered in a previous paragraph.

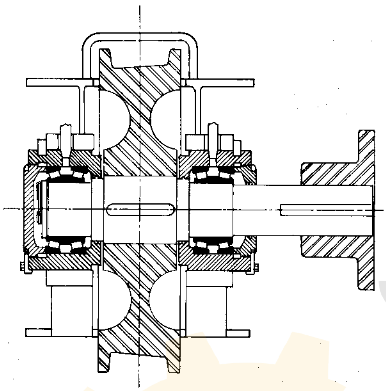


Fig. 28

BRIDGE WHEELS: The load carrying ability of bridge wheels is influenced by several factors, namely the wheel diameter, the material with which the wheel is made and the rail on which the wheel will travel.

Larger wheels of the same material will have greater load carrying capacity than smaller wheels; this statement does not hold true in comparing wheels of different materials. For example, a larger cast iron wheel may not have the load carrying capacity of a smaller rolled steel wheel. Besides affecting the load carrying ability of wheels, the diameter also affects the choice of ratio used in the bridge gearing. The larger the wheel diameter the more reduction ratio is required in bridge drive gears to give desired bridge speed.

Wheels may be of the following material, given in the order of their quality: cast iron, cast steel, iron with chilled treads, forged steel, rolled steel, rim-toughened, flame-hardened forging, induction-hardened forging and case hardened steel. Cast iron is used only for hand-powered cranes. Cast or rolled steel is considered standard for Classes A, B, and C; rolled steel for Classes C and D; rim-toughened rolled steel for Class E. Hardened treads are required for Class F.

Tables 2, 3 and 4 give the recommended wheel load and size of runway rail for the most popular diameter bridge wheels of rolled steel material:

Table 2: Maximum Wheel Load For Rails — Class A, B and C Cranes (1600 x D x W)

Wheel Dia. (D) Inches	ASCE 25#	ASCE 30#	ASCE 40#	ARA-A 90#	ASCE 60 & 70# ARA-A 100#	ASCE 80 & 85# ARA-A 100# Beth. 104# U.S.S. 105#	ASCE 100#	U.S. Steel Illi-nois 135#	U.S. Steel Illi-nois 175#	Beth-lehem 171#
8	12800	13610	16000							
10	16000	17010	20000	26600	28000					
12	19200	20410	24000	31900	33600	36000	40800			
15		25510	30000	39800	42000	45000	51000			
18		30610	36000	47800	50400	54000	61200			
21			42000	55800	58800	63000	71400	75600	105000	117600
24				63800	67200	72000	81600	86400	120000	134400
27						81000	91800	97200	135000	151200
30						90000	102000	108000	150000	168000

Table 3: Maximum Wheel Load for Rails — Class D Cranes (1400 x D x W)

Wheel Dia. (D) Inches	ASCE 25#	ASCE 30#	ASCE 40#	ARA-A 90#	ASCE 60 & 70# ARA-A 100#	ASCE 80 & 85# ARA-A 100# Beth. 104# U.S.S. 105#	ASCE 100#	U.S. Steel Illi-nois 135#	U.S. Steel Illi-nois 175#	Beth-lehem 171#
10	14000	14880	17500	23200	24500					
12	16800	17860	21000	27900	29400	31500	35700			
15		22320	26250	34900	36750	39380	44630			
18		26790	31500	41800	44100	47250	53550			
21			36750	48800	51450	55130	62480	66150	91880	102900
24				55800	58800	63000	71400	75600	105000	117600
27						70880	80330	85050	118130	132300
30						78750	89250	94500	131250	147000

Table 4: Maximum Wheel Load for Rails — Class E Cranes (1200 x D x W)

Wheel Dia. (D) Inches	ASCE 25#	ASCE 30#	ASCE 40#	ARA-A 90#	ASCE 60 & 70# ARA-A 100#	ASCE 80 & 85# ARA-A 100# Beth. 104# U.S.S. 105#	ASCE 100#	U.S. Steel Illi-nois 135#	U.S. Steel Illi-nois 175#	Beth-lehem 171#
10	12000	12760	15000	19900	21000					
12	14400	15310	18000	23900	25200	27000	30600			
15		19130	22500	29900	31500	33750	38250			
18		22960	27000	35900	37800	40500	45900			
21			31500	41800	44100	47250	53550	56700	78750	88200
24				47800	50400	54000	61200	64800	90000	100800
27						60750	68850	72900	101250	113400
30						67500	76500	81000	112500	126000

Table 5: Effective Width of Rail Head (W) Inches

1.000	1.063	1.250	1.656	1.750	1.875	2.125	2.250	3.125	3.500

Bridge wheels can be supplied with either straight, Figure 29, or tapered, Figure 30, treads. Tapered tread wheels have the advantage of keeping a crane square with the runway. Should one end of a crane with tapered tread wheels tend to skew or advance ahead of the opposite end, the leading wheel would tend to rotate on its low side of the taper while opposite and trailing wheel would tend to rotate on its high side of the taper tread, causing it to speed up in relation to the rail. This action promptly corrects the relative position of both ends of the crane bringing the crane back to "square" with the runway. The

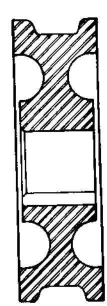


Fig. 29

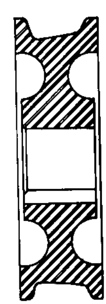


Fig. 30

high side of the taper as shown in Figure 30 must be toward the center of the span or adjacent to the inside bearing of the truck. To minimize rail wear, both driver and idler wheels should be tapered.

Straight tread wheels should have a tread width at least equal to the rail head width plus ⅜ to ½ inches. This dimension on tapered tread wheels should not be less than rail head width plus ¾ inch, or up to 1½ inches if end clearance is available.

CRANE BUMPERS: We should differentiate between stops and bumpers by considering stops as devices whose objective is to limit travel of trolley or bridge, and bumpers as energy-absorbing devices for reducing impact when a moving trolley or bridge reaches the end of its permitted travel. Bumpers may be spring, hydraulic, rubber, polyurethane, or other shock-absorbing materials. The prime function of the bumper is to protect cranes from damage due to hitting stops at the end of the runway or contacting other cranes on the same runway. Typical installation of a spring bumper is shown in Figure 31. See Section XIV, page 186, for determination of bumper requirements.

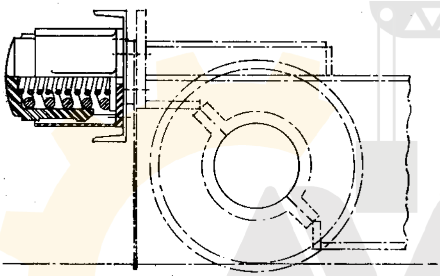


Fig. 31

RAIL SWEEPS: As a safety precaution, rail sweeps, Figure 31, should be provided in front of each wheel to brush away any object that may fall on the track.

BRIDGE DRIVES: A bridge consists of a power source (motors or handchains), suitable gearing and at least one driven wheel on each end of the bridge connected by a cross-shaft that extends the full length of the bridge, or in the case of a motor at each truck, connected by electrical circuit.

The first step in the design of a bridge drive is the selection of the bridge speed. This was discussed in Section V. After the bridge speed is selected the next step is to determine size of motor. The horse-power required can be computed from the formula:

$$HP = \frac{W \times FPM \times TE}{33000}$$

W = Total weight of crane and rated load, in tons.
FPM = Feet per minute.
TE = Tractive effort constant. See Table 6.

NOTE: The above calculation of bridge drive horsepower assumes that AC motors are to be used. See Section IX, Part C, for a discussion of motors for bridge drive use.

Table 6 — Tractive Effort Constant for Roller Bearing Bridges

FPM	CONSTANT	FPM	CONSTANT
50-150	30	350-450	45
150-250	35	450-550	50
250-350	40	600	55

The various tractive effort constants listed in the table above will provide approximately the same rates of acceleration for the bridge speed given. The tractive effort constant used in the horsepower formula above will give a rate of acceleration of about 1 foot per second per second, based on using the average motor torque available at 170% during the accelerating period. Higher tractive effort constants for the same bridge speed will provide rates of acceleration above 1 foot per second per second. Acceleration rates above 2.5 feet per second per second may produce skidding of the wheels. High rates of acceleration are desirable on high speed cranes, Classes E and F, since these cranes are usually involved in meeting a duty cycle and it is therefore, advantageous to quickly bring the crane up to rated speed. Where no duty cycle or high bridge speed is required, a low rate of bridge acceleration is satisfactory and results in a smaller bridge motor thus reducing original and operating costs. A 1 foot per second per second acceleration rate is recommended to give smooth operation and to prevent swinging of the load.

For outdoor cranes it is necessary to increase the horsepower of the bridge motor to accommodate the 10 pounds per square foot resistance to motion set up by winds of 30 to 40 MPH. The wind resistance is figured on the projected area of the crane in the exposed direction based on a horizontal wind only. The 10 pounds per square foot makes allowance for wind on exposed surfaces other than the vertical face considered. The bridge motor horsepower must be equal to the running horsepower plus the horsepower to overcome the 10# wind with the bridge moving against the wind at ½ rated speed.

Knowing the bridge speed, the full load RPM of the bridge motor and the circumference of the bridge wheels, substitution in the following formula gives the ratio required in the bridge drive case:

$$\text{Ratio} = \frac{\text{RPM} \times \text{C}}{\text{FPM}}$$

RPM = Full load motor RPM

C = Circumference of bridge wheels in feet.

Table 7

Wheel Dia.		C
12	=	3.14
15	=	3.92
18	=	4.71
21	=	5.50
24	=	6.28
27	=	7.06
30	=	7.85

Once the horsepower and ratio required in the bridge drive case are known a suitable selection of a drive case can be made from standard units as designed by the crane manufacturer in accordance with the best machinery design practices for shafting, gearing and bearings.

Bridge drives with cross-shafts may be either of the single unit, Figure 32, or double unit, Figure 33, type. A bridge motor connected by a flexible coupling to the bridge drive case, mounted close to the

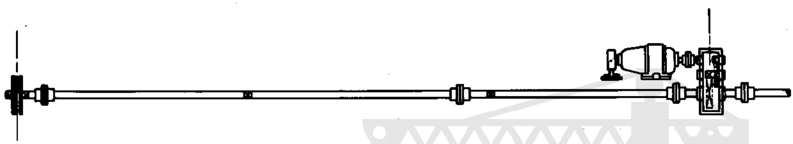


Fig. 32

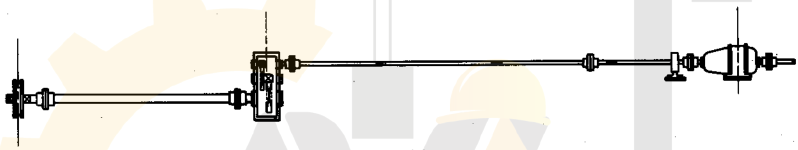


Fig. 33

center of the span, constitutes a single unit drive and is ordinarily used on cranes up to 90 foot span. In this single unit arrangement, the entire length of cross-shaft is rotating at the output RPM of the drive case. Double bridge drives are used on cranes of spans greater than 90′-0″. In the double unit arrangement, a bridge drive motor is mounted at the center of the bridge span and cross-shafts that rotate at the motor RPM extend to both ends of the bridge to double reduction units mounted 12 to 15 feet from each runway rail. Slow speed cross-shafts rotating at the output RPM of the bridge drive cases extend to the drive wheels at each end of the bridge. With these drives there is no gearing at the truck, thereby eliminating the difficult problem of enclosing the gearing between the truck bearings or permitting the use of overhung gears.

In selecting the cross-shaft for a bridge drive the torsional deflection of the shaft becomes the determining factor because of the importance of having an equal driving effort applied at each drive wheel. By limiting torsional deflection to .08° per foot, "wind up" or twist of the cross-shaft is prevented. Flange type couplings are used to connect the cross-shaft to the bridge drive and the bridge wheel axles. Intermediate points of support are provided the cross-shaft by ball bearing "pillow block" bearings, so spaced that "whip" of the shaft, especially the high-speed cross-shaft, is eliminated.

Bridge drives without cross-shafts have a motor and enclosed gear reducer at one or more wheels on each side of the crane. These motors are kept in step electrically so that the speed at each wheel remains constant with each other to assure bridge travel without skewing.

BRAKES: Besides speed controls for the bridge motor, it is necessary to provide a bridge brake to accurately control the position of a crane bridge. These brakes should be capable of stopping the full load at full speed within a distance equal to 10% of the full load speed in feet per minute of the bridge. On floor controlled cranes, Class A, B and C solenoid bridge brakes are frequently used. These brakes are spring set and held in the released position by the solenoid. Releasing the push button controlling bridge motor current disrupts both the motor and brake solenoid current thus setting the brake. A typical solenoid bridge brake is shown in Figure 34.

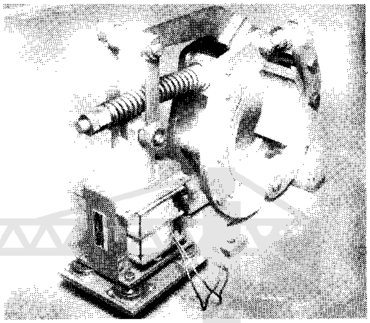


Fig. 34

On cab-controlled cranes hydraulic brakes are used almost exclusively. These brakes give complete control of all braking requirements usually encountered on cranes. For cranes used in outside service, hydraulic brakes can be provided that include a parking brake. Where conditions are such that very high brake pedal pressures are encountered or brakes are applied so frequently as to be unduly fatiguing, powered hydraulic brakes can be supplied. Figures 35 and 36, show some of the hydraulic brake installations that are available.

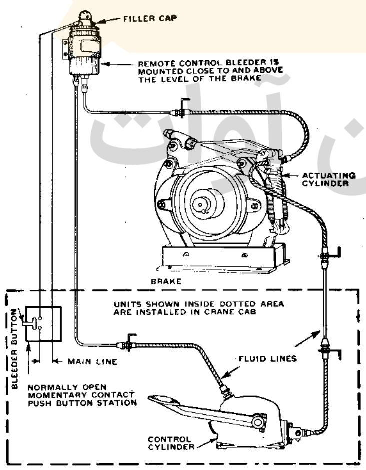


Fig. 35

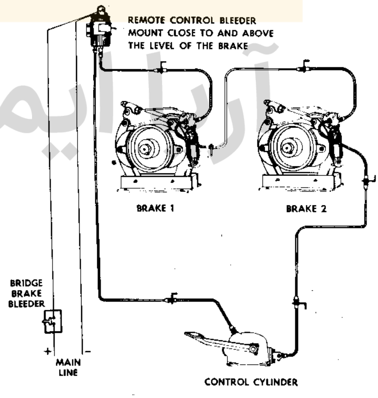


Fig. 36

Bridge brakes are selected from manufacturer's ratings based on the following formula:

$$T = \frac{HP \times 5250 \times S}{RPM}$$

T = Braking torque in foot-pounds.
HP = Horsepower of bridge motor.
RPM is for shaft on which brake is mounted.

S = .75 Class A; 1.0 Classes B, C, D; 1.25 Class E; 1.50 Class F.

BRIDGE WALK: A feature contributing to ease of maintenance of cranes is the footwalk along the drive girder. Footwalks are required on all cab-controlled cranes and on some of the floor-controlled cranes. These walks are designed to incorporate safety features including safety tread floor plate, handrails with an intermediate horizontal member and toeboards on edges of the walk to prevent workmen's tools from being pushed off the footwalk. Adequate, protected working space is thus provided, for inspecting, servicing and lubricating the bridge drive machinery and those parts of the trolley accessible from the footwalk. Typical views of footwalks are shown in Figures 37 and 38. Minimum clearance around motors and drives should be 15 inches, at least 5′-0″ is provided from walk to roof truss. Handrails are 3′-6″ high and toeboards 6″ high. Walks are designed for a distributed load of 50 pounds per square foot.

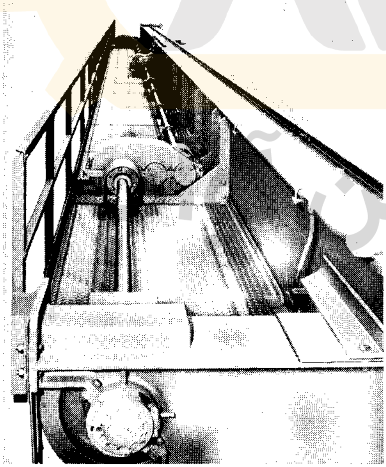


Fig. 37

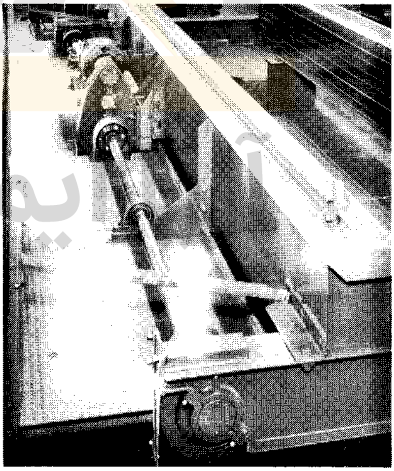


Fig. 38

Footwalk-equipped electric cranes with wide flange beam girders should have an auxiliary girder paralleling the bridge drive and walk. For cranes up to 40 foot span, the auxiliary girder is usually a heavy channel with members to form the hand rail for the walk. Above 40 foot span the members of the hand rail form a truss, Figure 39.

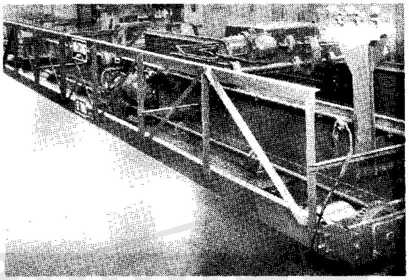


Fig. 39

BRIDGE CONDUCTORS: The supplying of current and control from the fixed wiring of the bridge to the trolley may be done through several mediums.

The most popular method is to stretch bare copper wires across the bridge span between anchors located at each end of the bridge. End anchors for the wires are shown in Figure 40. For spans between 60 and 82 feet, intermediate slapping strips on 20 foot centers must be provided if wires are adjacent to girder webs. Spans above 82 feet require intermediate supports of the insulator or peg type, spaced on 20 to 50 foot centers. Minimum vertical spacing of wires for shoe collectors is 3½ inches. Wire sizes are determined by current-carrying capacity, mechanical strength and wear for the spans desired are shown in Table 8.

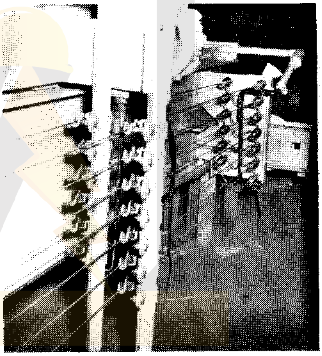


Fig. 40

Table 8

50°C Rise @ 25° Ambient

Wire B & S Gauge	Max. Amperes	Spans
No. 6	125	0 to 30 ft.
No. 4	165	31 to 60 ft.
No. 2	225	over 60 ft.
No. 0	300	over 60 ft.
No. 00	350	over 60 ft.
No. 000	405	over 60 ft.
No. 0000	470	over 60 ft.

Flat bars, angles, tees, and rail of steel, copper or aluminum are also used as bridge conductors. These assure long life but are made expensive because they must be supported on 6 to 9 foot centers in order to assure alignment for proper collector shoe action. Maximum spacing of supports must not exceed 80 x vertical dimension of conductor.

To avoid conductor wear induced by collector contact and the maintenance of collectors, the use of multi-conductor flexible cables is becoming more acceptable. These cables are looped and supported from movable trolleys on track which in turn is mounted on the bridge girders or footwalk railing. Cable reels may also be used.

Both of these methods eliminate open conductors and permit cranes to be used in dangerous and explosive areas.

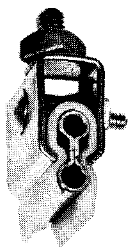


Fig. 41

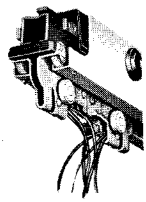


Fig. 42

Under some operating conditions or local regulations, no exposed wiring would be permitted. For these conditions, several types of enclosed conductors have been developed, Figures 41 and 42. In these systems the conductor member is protected by ducts or sheaths and the collector surface operates within the enclosure. These systems are expensive from both a material and installation standpoint and are recommended only where absolutely necessary.

COLLECTORS: In this category we will consider only those collectors mounted on the bridge for pick-up of current from the runway conductors. Trolley collectors will be considered in Part B — Trolley Design.

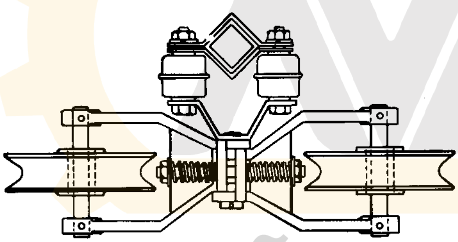


Fig. 43

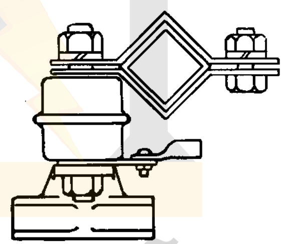


Fig. 44

For wire conductors with rigid intermediate supports, the spring type double-wheel collector, Figure 43, is the most popular. Bronze sliding shoes, Figure 44, or sliding shoes with carbon inserts, Figure 45, are used for wires mounted on spool-type intermediate supports. The tandem-wheel collector, Figure 46, is also used for this type conductor.

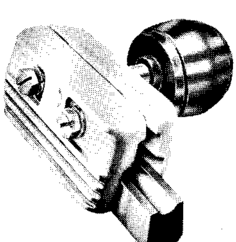


Fig. 45

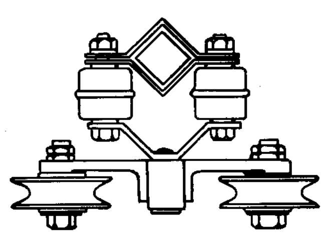


Fig. 46

The flat shoe collector, Figure 47, is used for top-wipe of angles, flat bars, tees and rails.

The spring tension shoe, Figure 48, is used for underwipe contact for angles and rails. The inverted type, Figure 49, is recommended as preferred for outdoor service of cranes in Classes E and F.

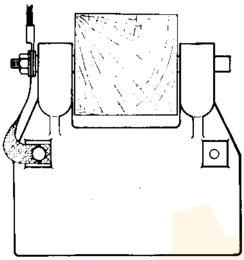


Fig. 47

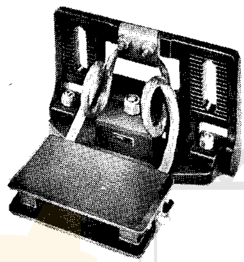


Fig. 48

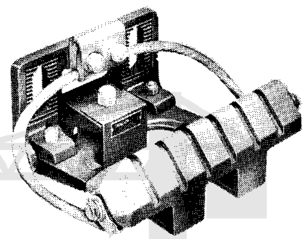


Fig. 49

CONTROL PLATFORMS: On floor-controlled cranes in Classes A, B, C or D, a structural platform that may be mounted at any location on the bridge, or may be mounted on the trolley, is required to support the controllers, resistors, and switch. This may be a simple bracket of ample size to contain all the electrical equipment.

CABS: Crane cabs may be divided into two major divisions, open for indoor service and enclosed for outdoor service or indoor where conditions make it necessary for operator comfort.

Fig. 50

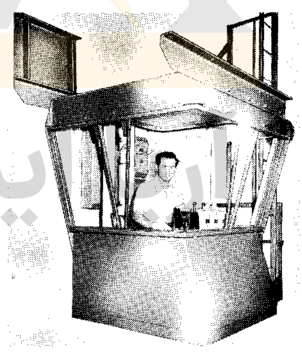


Fig. 51

Open cabs are so called because they require no enclosure beyond that required for structural and safety reasons. The pulpit type cab, Figure 50, is most popular because of the high angle of visibility furnished the operator. A complete hand rail with protected opening for access must be supplied as well as a ladder or other means of access to the crane footwalk.

Enclosed cabs must have provision for maximum operator visibility with emphasis on the view of the crane hook in its extreme travels. The cab should be provided with safety glass, an access platform, and ladder to bridge footwalk, Figure 51. Provision should be made for cab ventilation by opening of windows or mechanically with a ventilating system. A heater for cold weather operation is required. Air-conditioning, especially for cabs operating in extremely hot areas, is now being used. Cost of equipment and the added cost of a cab requiring complete insulation and double glass make this feature expensive; however, this increased cost is justified by the improved efficiency and working conditions of the crane operator, especially in Class E and F cranes.

The cab may be located at any position along the bridge girder or on the trolley overhanging the idler girder or between the girders as a trailer cab. Operating conditions usually determine the position of the cab, but the crane builder would prefer the end of bridge location for lower cost and better rigidity.

The size of cab is determined by the type of control, the number of motions of the crane, operator comfort and the policy of the user regarding number of men to be in the cab, especially during training periods.

Regardless of type, style or size of cab, efficiency in arrangement of controllers, good visibility, safety, and operator comfort must be considered in the design of the cab. Types and arrangement of control and wiring details will be discussed in the electrical design of this Section in Part C.

PART B – TROLLEY DESIGN

This part of the Crane Design Section will be devoted to the components that make up a crane trolley, namely load blocks, ropes, drums, hoist cases, brakes, limit switches, trolley travel drives, wheels, frame, collectors and auxiliary hoist.

A combination of gearing and rope reeving is used to convert the motor torque and speed to "pull" at the crane hook in order to keep down the weight and size of the trolley. The weight affects the bridge and runway design; and the size, if small, permits additional hook travel at the sides and ends of the crane runway.

Some consideration must be given to the efficiency of space covered by the crane hook. This can be measured by the volume of hook coverage, that is the travel distance parallel to the bridge girders, multiplied by the travel distance of the bridge on the runway multiplied by the vertical travel of the hook. The space required from the hook in high position to the top of trolley determines the actual height of building required to provide a specified lift. Efficient design of the trolley will provide, (1) additional movement on the bridge due to a short wheelbase trolley frame, (2) additional bridge travel on the runway due to narrow gauge of trolley and (3) a vertical hook travel consistent with a minimum height of building. The volume of coverage may be a factor of value when comparing the cost of cranes which otherwise are of equal quality.

The slower the speeds selected that will perform the given job, the smaller the motors required; this in turn permits the use of smaller gear drives which all tend toward a lighter weight trolley with the subsequent savings in bridge and runway initial cost plus the operating savings due to lower power consumption for all three motions of the crane.

Figure 52 shows a typical trolley of 10 ton capacity for Class D service.

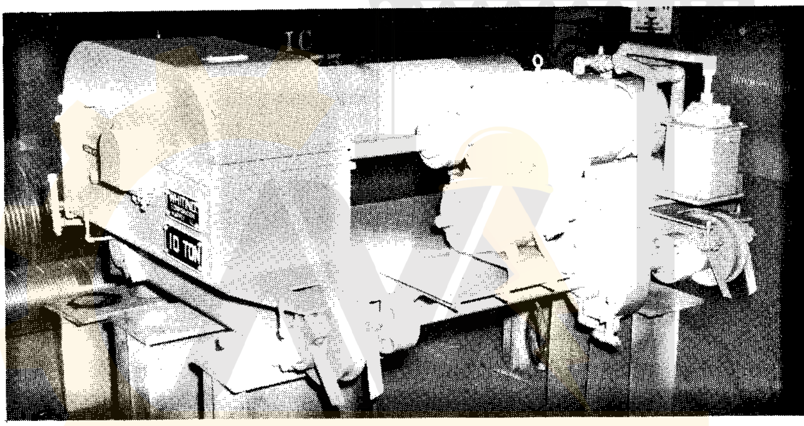


Fig. 52

LOAD BLOCKS: In a detailed discussion of the various components of a trolley, the load block is a logical starting point. The basic parts of a block are the hook, thrust bearing, hook swivel, sheaves, sheave bearings, sheave pin, side plates, keeper plates, covers, bearing retainers and miscellaneous parts as shown in Figure 53.

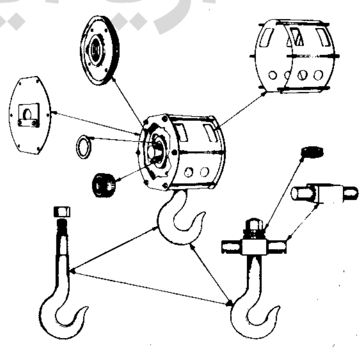


Fig. 53

Hooks for cranes of 5 to 50 ton capacity are usually forged from carbon, or alloy steel. Above 50 ton capacity the hooks may be burned from a slab of steel and machined to the required contours. On cranes of less than 60 ton capacity single hook blocks are used. For 60 ton and over either single or sister hooks may be furnished although for capacities of

75 ton and above, sister hooks are preferred both from the standpoint of more favorable design and versatility in use. Figure 54 and Table 9 give the contour and dimensions of a single hook. Figure 55 and Table 10 give the same information for a sister hook. Figure 56, 57 and 58 show typical load block arrangements with enclosures removed.

Good design practice requires that load blocks be enclosed. The enclosing of blocks permits generous lubrication of the wire rope and sheave bearings, and with a flange at the hook opening prevents the dripping of lubricant on workmen, floor or valuable materials. In addition, enclosed blocks provide greater safety by keeping workmen away from moving cables and rotating sheaves.

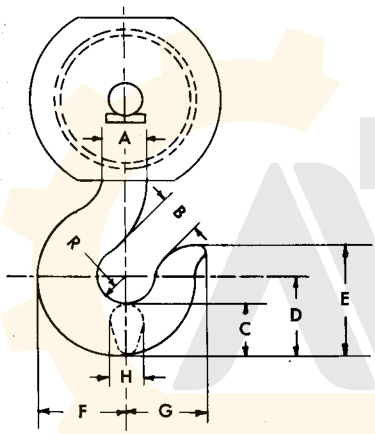


Fig. 54

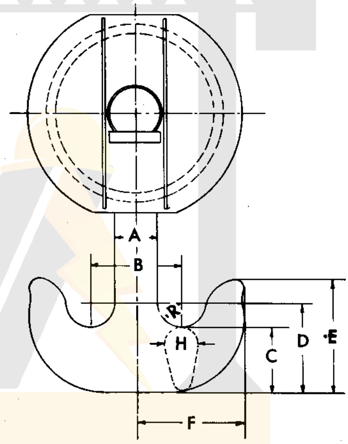


Fig. 55

Table 9 — Single Hook Dimensions in inches (Fig. 54)

Capacity In Tons	A	B	C	D	E	F	G	H	R
5	1 1/2	2 1/4	2 1/8	3 5/8	5 3/8	4	3 7/16	1 5/8	1 1/2
10	2	3 3/8	3	5 1/8	7 5/16	5 5/8	5 3/8	2 3/8	2 1/8
15	2 1/2	4	3 5/8	6 1/8	8 3/4	6 7/8	6 1/2	2 7/8	2 1/2
20	2 1/2	4	3 5/8	6 1/8	8 3/4	6 7/8	6 1/2	2 7/8	2 1/2
25	2 1/2	4	3 5/8	6 1/8	8 3/4	6 7/8	6 1/2	2 7/8	2 1/2
30	3	4 1/4	4 9/16	7 1/4	11 5/16	7 11/16	6 3/8	3 3/4	2 11/16
40	4 1/8	5 3/4	6	9 1/2	14 3/4	10	8 1/2	4 5/8	3 1/2
50	4 1/2	6 1/2	6 11/16	10 9/16	16 7/16	11 1/8	9 1/2	5	3 7/8
60	5 7/16	9 9/16	8 1/2	13 5/8	17 5/8	14 3/4	13 3/4	6	4 7/8
75	5 7/16	9 9/16	8 1/2	13 5/8	17 5/8	14 3/4	13 3/4	6	4 7/8
100	6 13/16	8	10 3/4	15	19 1/2	17 1/4	14 1/2	7 1/2	4 1/4
125	7	8	11 3/4	16	20 1/2	18 1/4	14 1/2	7 1/2	4 1/4
150	7 1/4	10 1/4	12	18	25 1/2	22	14 1/2	10	6
200	8	9 3/4	15	21	33	26	20	12	6

Table 10 — Sister Hook Dimensions in inches (Fig. 55)

Capacity In Tons	A	B	C	D	E	F	H	R
50	$5\frac{7}{16}$	12	7	10	13	13	$4\frac{3}{4}$	3
60	$5\frac{7}{16}$	12	7	10	13	13	$4\frac{3}{4}$	3
75	$5\frac{7}{16}$	$12\frac{1}{2}$	$8\frac{1}{4}$	$11\frac{1}{2}$	$14\frac{1}{2}$	14	$4\frac{5}{8}$	$3\frac{1}{4}$
100	6	13	$8\frac{3}{4}$	12	15	15	$5\frac{1}{4}$	$3\frac{1}{4}$
125	$6\frac{13}{16}$	$15\frac{1}{2}$	11	15	19	18	$6\frac{1}{8}$	4
150	$7\frac{1}{4}$	$15\frac{1}{2}$	11	15	$19\frac{1}{2}$	18	$6\frac{1}{2}$	4
200	8	17	12	$15\frac{3}{4}$	$21\frac{3}{4}$	$17\frac{1}{2}$	$9\frac{1}{2}$	$3\frac{3}{4}$
250	9	$19\frac{1}{2}$	14	19	24	22	$9\frac{1}{2}$	5

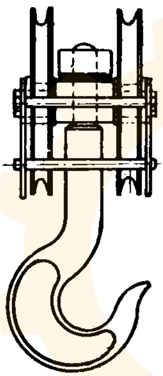


Fig. 56

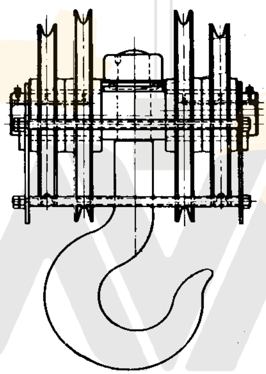


Fig. 57

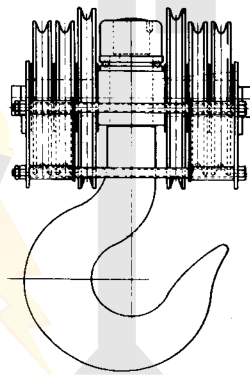


Fig. 58

If open blocks are used, guards must be provided to prevent the hoisting ropes from leaving the sheave grooves even when the block is in such a position that a slack rope condition is developed.

Rope sheaves should be accurately machined and smoothly finished to reduce rope wear. Proper rope clearance should be provided as shown in Figure 59 which shows recommended grooving for sheaves.

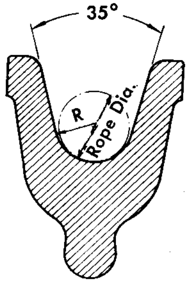


Fig. 59

Rope Diameter	Sheave Groove Radius R = ½ Rope Dia. + Following Dim.
¼ — 5/16	1/64
⅜ — ¾	1/32
⅞ — 1⅛	3/64
1¼ — 1½	1/16

The efficiency of load blocks is a function of the type of bearings used in the sheaves and the number of sheaves. Table 11 shows the efficiency of blocks equipped with roller bearings for various parts of rope. The following unit on wire rope shows the number of parts of rope and rope sizes that are standards for various capacity cranes.

Table 11 — Efficiency of Load Blocks (Double-Reeved)

Parts of Rope	Efficiency Roller Brg.	Efficiency Plain Brg.	Lead Line Factor Roller Brg.	Lead Line Factor Plain Brg.
2	1.000	1.000	.500	.500
4	.981	.959	.255	.261
6	.962	.920	.173	.181
8	.944	.883	.132	.141
10	.926	.848	.108	.118
12	.909	.815	.092	.102
16	.875	.754	.071	.083
20	.843	.700	.059	.071
24	.813	.650	.051	.064

WIRE ROPE: Wire rope used as hoisting rope is usually of the 6 x 19 or 6 x 37 type. These numbers indicate the number of strands per rope and also the number of individual wires per strand. Thus each type of rope mentioned has 6 strands, the first having 19 wires per strand and the second 37 wires. See Figures 60 and 61. The 6 x 37 rope, having a greater number of smaller diameter wires, is a more flexible rope and can be safely used with smaller diameter drums and sheaves. These wire ropes can be obtained with either steel core or fiber core centers. Fiber core is the usual choice because of its greater flexibility and lubricant-holding property. Where cranes are used under high temperature conditions however, such as encountered with charging or hot metal handling cranes, steel core ropes are specified. Besides a choice of centers, the above types of rope are supplied in either improved plow steel with a rated tensile strength between 225,000 and 295,000 pounds per square inch, or alloy steel with a rating of 260,000 to 340,000 PSI.

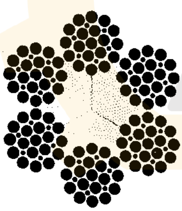


Fig. 60

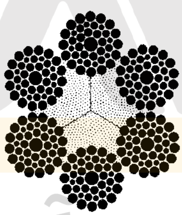


Fig. 61

Table 12 gives the weight per foot and the breaking strength of wire ropes used in crane service. To obtain the safe working load for each diameter of rope, divide the breaking strength by the factor of safety. This factor may be 4 for Class A service, should be not less than 5 for Class B, C. D and E, and from 6 to 8 for Class F service.

Table 12 — Weight and Strength of Wire Rope — 6 x 37 Type

Dia. In Inches	Weight Per Ft. (lbs.) Fiber Core	Weight Per Ft. (lbs.) Steel Core	Breaking Strength in Tons: Improved Plow Steel Fiber Core	Improved Plow Steel Steel Core	Alloy Steel Steel Core
1/4	.10	.11	2.59	2.78	3.20
5/16	.16	.18	4.03	4.33	4.98
3/8	.22	.24	5.77	6.20	7.14
7/16	.30	.33	7.82	8.41	9.67
1/2	.39	.43	10.2	10.97	12.6
9/16	.49	.54	12.9	13.87	15.9
5/8	.61	.67	15.8	16.99	19.5
3/4	.87	.96	22.6	24.30	27.9
7/8	1.19	1.31	30.6	32.90	37.8
1	1.55	1.71	39.8	42.79	49.2
1-1/8	1.96	2.16	50.1	53.86	61.9
1-1/4	2.42	2.66	61.5	66.11	76.0
1-3/8	2.93	3.22	74.1	79.66	91.6
1-1/2	3.49	3.84	87.9	94.49	109.

Utilizing the principle of the tackle block, the drum pull is multiplied by the reeving to obtain the hook pull and divided by the reeving to obtain the hook speed. Doubling the number of parts of rope, for example, would double the lifting capacity of the block and reduce the hoisting speed by one half. Table 13 shows the accepted reeving and size of ropes for different capacities.

Table 13 — Parts of Rope & Rope Dia. for Various Crane Capacities
Factor of Safety = 5

IMPROVED PLOW STEEL — FIBER CORE ROPE

Capacity Tons	Parts of Rope	Rope Diameter	Reeving Figure p. 82
5	2	5/8	R-1
5	4	7/16	R-2
7-1/2	4	1/2	R-2
10	4	9/16	R-2
15	8	1/2	R-3
20	8	9/16	R-3
25	12	9/16	R-4
30	12	9/16	R-4
40	8	7/8	R-3
50	8	1	R-3
60	12	7/8	R-4
75	12	1	R-4
100	12	1-1/8	R-4
125	16	1	R-5
150	16	1-1/8	R-5
175	16	1-1/4	R-5
200	24	1-1/8	R-6
250	16	1-3/8 Alloy	R-5

REEVING DIAGRAMS

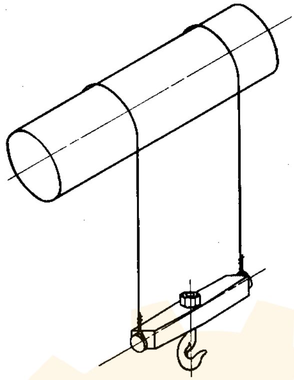


Fig. R-1

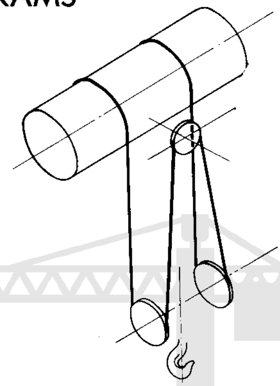


Fig. R-2

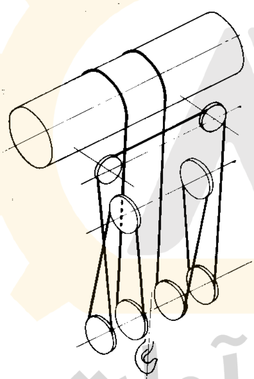


Fig. R-3

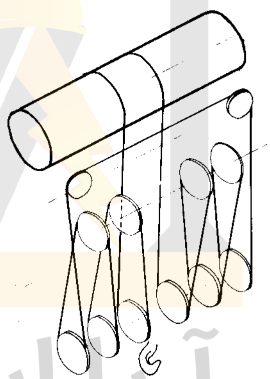


Fig. R-4

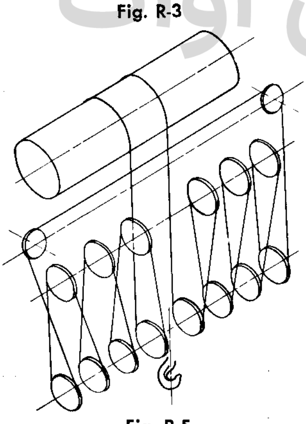


Fig. R-5

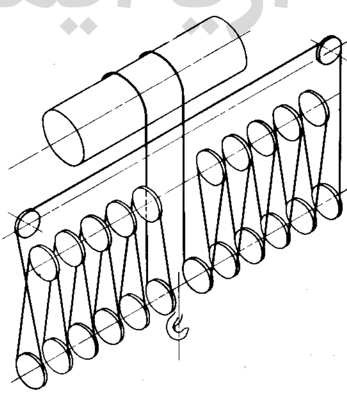


Fig. R-6

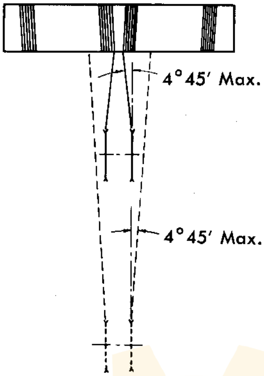


Fig. 62

The lines attached to the drum, lead lines, have an additional load above the other lines between sheaves caused by the friction of sheaves from the equalizer to the drum. The actual load in each of these lines is found by multiplying the rated hook load by the lead line factor in Table 11 for the reeving of ropes and the type of bearings in the sheaves.

The lead, or fleet angle, of the ropes relative to drums and sheaves must be considered if maximum life of ropes, drums, and sheaves is to be obtained. This angle shown in Figure 62 should not exceed the ratio of 1 to 12, or 4° 45′.

The rope manufacturers recommend minimum and desired ratios of drum and sheave diameters to rope diameter for the maximum life of rope. For cranes in Class A, B, C, D, or E, using 6 x 37 wire rope, the ratio should be 24 to 1 and using 6 x 19 wire rope should be 30 to 1. For Class F cranes, the ratio should be 30 to 1 for 6 x 37 rope and 45 to 1 for 6 x 19 rope. For example, referring to Table 13, a 10 ton crane for Class D service would employ 4 parts of 9/16″ diameter improved plow steel rope. The standard drum and sheave diameter would be 9/16″ x 24 or 13-1/2″.

DRUMS: Hoist drums, of either cast or rolled plate construction, are hollow or tubular and must resist crushing stress imposed by the wire rope. In designing drums, this crushing stress is combined with bending stress to arrive at a combined compressive stress which must be within design limits for suitable operation and service life.

Drum thickness may be checked by the following formulae:

Consider load at center of drum.

$$Z = .0982\,\frac{D^4 - d^4}{D} \qquad S_b = \frac{WL}{4Z} \qquad S_c = \frac{P}{pt} \qquad S = \sqrt{S_b^2 + S_c^2}$$

D = Diameter of drum at bottom of groove in inches.
d = Inside diameter of drum in inches.
t = Thickness of drum at bottom of groove in inches.
Z = Section Modulus at bottom of groove (neglect ribs).
W = Load on drum in pounds.
P = Load per rope in pounds — lead line rope.
L = Length of drum (center to center hubs) in inches.
S_b = Stress due to bending. 3500 PSI for cast iron.
S_c = Stress due to crushing. 10,600 PSI for cast iron.
S = Combined stress. 11,200 PSI cast iron, 14,000 PSI steel.
p = Pitch of grooving, center to center of grooves.

It has been found by actual field service that the addition of a hardened sleeve with smooth grooves on the hoist drum of Class E and F service cranes, will give 3 times the rope life and at least 3½ times the drum life when compared with ordinary drums. The initial cost is high, but the later savings in rope and drum replacement and the down-time of the crane will make this an investment worthy of consideration.

Table 14 — Drum Grooving in inches

Rope Dia. RD	Pitch Dia. Drum PD	with P = RD + 1/8 outside diameter OD	A	with P = RD + 1/4 OD	A	B	R
3/8	9	9	—	9	—	1/32	7/32
7/16	10-1/2	10-1/2	—	10-1/2	—	1/32	1/4
1/2	12	12	—	12	—	1/32	9/32
9/16	13-1/2	13-7/16	1/32	13-1/2	—	1/32	5/16
5/8	15	14-15/16	1/32	15	—	1/32	11/32
9/16	17	16-15/16	1/32	17	—	1/32	5/16
3/4	18	17-7/8	1/16	18	—	1/32	13/32
7/8	21	20-7/8	1/16	21	—	3/64	31/64
1	24	23-13/16	3/32	24	—	3/64	35/64
1-1/8	27	26-3/4	1/8	27	—	3/64	39/64
1-1/4	30	29-11/16	5/32	30	—	1/16	11/16
1-3/8	33	32-5/8	3/16	32-3/4	1/8	1/16	3/4
1-1/2	36	35-5/8	3/16	35-3/4	1/8	1/16	13/16

Figure 63 shows a section of drum grooving dimensioned for use with Table 14. Figure 64 shows an entire drum which is provided with right and left hand grooves. Correct grooving on a drum not only keeps the rope in place but also gives the rope additional support which reduces bending in the wire rope and increases its service life. Besides providing grooves for all the rope needed to make the required lift, drums are provided with two dead grooves at each of the two anchor points. The function of the dead grooves is to relieve the rope anchor from being subjected to the full tension in the rope. Typical installation of the rope anchor is shown in Figure 65.

Where extremely long lifts are required, a single layer cannot always accommodate the rope on the drum. Multiple layers of rope are used in these instances along with a level winding device to spool the wire rope evenly on the drum.

Figure 64 also illustrates the application of the drum gear to the drum. This is usually a shrink fit on the drum diameter and further secured by dowels or keys. Note that the gear is not applied to the drum shaft or the drum hub, thereby eliminating torsion stresses in those parts.

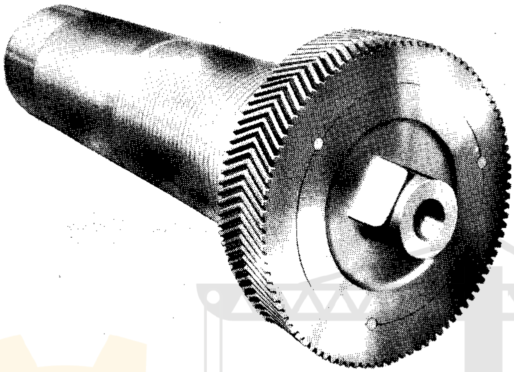


Fig. 64

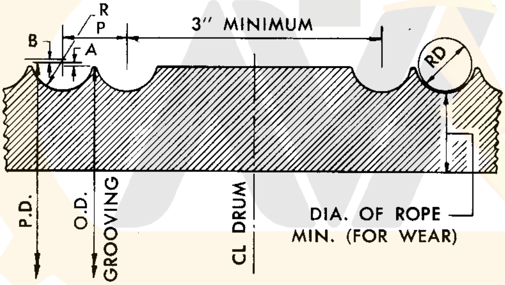


Fig. 63

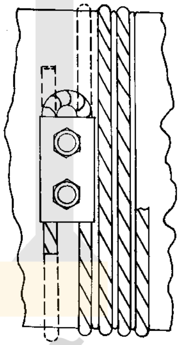


Fig. 65

HOIST CASES: Before going into a discussion of hoist case details, a study of hoist machinery layouts should be made. Keeping in mind that the motor torque must be transformed into rope pull at the drum with the highest possible efficiency, the least number of gear reductions between motor and drum is important and again stresses the fact that the slower the speed, the smaller the motor results in a lighter crane and runway required to do a specific job.

The use of efficient herringbone gears, permits the employ of only 2 reductions of gearing in most cranes up to 40 tons capacity. Figure 52 on page 77 shows a typical hoist machinery layout with motor connected by flexible coupling to a 2-reduction gear case in which the drum is a unit part. This arrangement has an efficiency of .950.

For slower speeds and higher capacities another gear reduction is introduced outside the hoist case as shown in Figure 66. This arrangement has an efficiency of .902 based on an open gearing reduction with .95 efficiency.

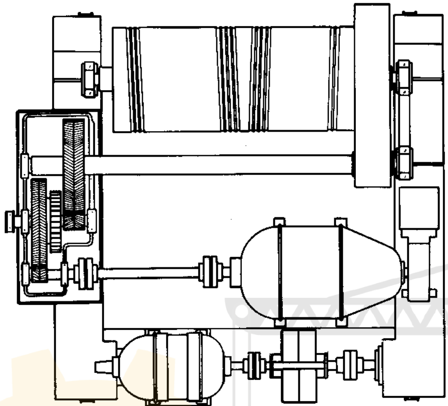


Fig. 66

Other types of hoist machinery layouts using geared-head motors, worm gear reducers, and other reductions must be calculated according to the drive manufacturer's rated efficiencies.

The motor horsepower is the determining factor in selecting a hoist drive. This is determined by the speed and rated load from the following formula: (See Section IX-C for discussion of crane motors.)

$$HP = \frac{W \times V}{33000 \times E_1 \times E_2}$$

W = Load in pounds.
V = Hoisting speed in feet per minute.
E_1 = Rope efficiency. Table 11, page 80.
E_2 = Gearing efficiency as above.

The following formula will give the hoist ratio to obtain speed shown in preceding formula:

$$\text{Ratio} = \frac{RPM \times D}{V \times R_1 \times R_2}$$

RPM = Full load motor speed.
D = Drum circumference in feet. Table 15.
V = Hoisting speed in feet per minute.
R_1 = Reduction in rope reeving equal to ½ the number of parts of rope for 2 ropes on drum.
R_2 = Ratio of extra spur reduction, if used.

Table 15 — Drum Circumferences

Drum Dia. Inches	Circumference Feet	Drum Dia. Inches	Circumference Feet	Drum Dia. Inches	Circumference Feet
10	2.62	21	5.50	37½	9.82
12	3.14	24	6.28	42	11.00
13½	3.53	27	7.07	48	12.58
15	3.92	30	7.85	54	14.15
17	4.45	33	8.64	60	15.72
18	4.72	36	9.42	72	18.85

After the horsepower and ratios have been determined, the following steps will check the gearing:

Tooth load on motor pinion and gear $= TL_m = \dfrac{HP \times 63025}{P.D.\ Pinion/2 \times RPM}$

Tooth load on drum pinion and gear $= TL_d = \dfrac{TL_m \times Motor\ Gear\ P.D. \times Efficiency}{Drum\ Pinion\ P.D.}$

Tooth load on drum gear figured from load $= TL_g = \dfrac{2 \times W \times drum\ diameter}{E_1 \times Parts\ of\ rope \times drum\ gear\ P.D.}$

Typical example for hoist gearing calculation covering 10 ton hoist at 55 feet per minute:

10 ton requires 4 parts of 9/16" diameter rope (double) table 13 (Page 81).

(1) Motor horsepower $= \dfrac{20000 \times 55}{33000 \times .981 \times .95} = 35.8$ (Page 86).

Use 40 HP motor at 1140 full load RPM

(2) Ratio $= \dfrac{1140 \times 3.93}{55 \times 2} = 40.6$

Pitch diameters of hoist case gearing = Motor pinion: 3.0"; Motor gear: 22.6"; Drum pinion: 4.5"; Drum gear: 24.0".

(3) Tooth load on motor pinion $= \dfrac{40 \times 63025}{3.0/\ 2 \times 1140} = 1475$

(4) Tooth load on drum gear $= \dfrac{1475 \times 22.6 \times .95}{4.5} = 7040$

(5) Tooth load on drum gear $= \dfrac{20000 \times 2 \times 15}{4 \times 24.0 \times .981} = 6360$

Allow for figured horsepower compared to actual and we find that (4) and (5) check.

From the tooth loads in the preceding formulae, the strength of gearing may be calculated according to the tooth forms, using the Lewis formula with the Barth velocity factor for 14½°, 20° full depth and 20° stub tooth gearing. Herringbone and helical gearing is given special consideration and is recommended because of its sturdy design and quiet, smooth, long-life performance.

Crane manufacturers have standard hoist cases with horsepower ratings for each ratio. The class of crane service dictates what factor shall be used in the application of these ratings. Properly applied heat-treatment will prolong the life of gearing and reduce the down-time of crane service.

BRAKES: The load on a crane must be under the control of the crane operator at all times to assure the safe handling of the load and the utmost safety for the operator and all floor personnel. The motors provide the acceleration of all movements and the brakes must furnish the control, stopping and holding of the load. In this section we are considering only the hoist brakes, one of which must always be automatic in operation and in no way dependent upon the crane operator.

To assure safety and accuracy of control, there shall be two independent systems of braking for each hoisting motion. One system shall include a holding brake which may be a spring-set, electrical release brake mounted on the motor or extension of one of the pinion shafts of the hoist gear case. The second system shall be a control braking means which may be mechanical, such as a load brake, or electrical such as dynamic braking, eddy-current brakes, or electrical circuits incorporating motor braking. The holding brake must be capable of stopping and holding the load and shall be applied automatically when power is removed. The control braking must be capable of maintaining safe lowering speeds of rated loads.

The mechanical load brake, if used, is interposed in the mechanism between the motor pinion and the hoisting drum.

The basic principle of the mechanical load brake is the automatic conversion of the kinetic energy produced in the descent of a load into heat which shall be dissipated from the friction surfaces to the atmosphere. It must be so designed that it will sustain the full load at rest, independent of any other brake, and control the lowering speed. A properly designed brake will require power to lower a load.

MECHANICAL LOAD BRAKE: To fulfill the above requirement, an automatic load brake of the friction disc type may be built into or made a part of the first gear reduction in the hoist case. Figures 67, 68 and 69 show the arrangement and details of such a mechanical load brake. Situated between the brake gear and pinion on the brake shaft is a ratchet wheel which can be stopped by a pawl actuated by linkage-action controlled by limited rotation of a friction sleeve mounted on the motor drive shaft. The ratchet wheel is provided with two friction washers and is free to idle on the brake shaft, but is held stationary when engaged by the pawl. The brake gear is not keyed to the brake shaft but transmits its torque to the shaft through a brake nut which turns on a screw that is an integral part of the shaft.

Starting the hoisting cycle causes the brake nut to advance along the screw in the direction of the ratchet wheel until the friction washers are engaged, at which point the entire assembly operates as if it were simply a shaft with a gear and pinion keyed to it.

When the motor is reversed to lower, the pawl is actuated by the

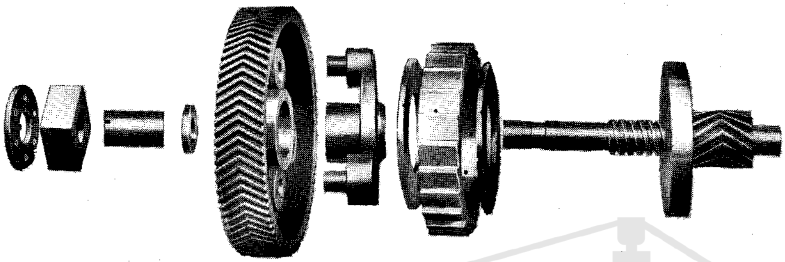


Fig. 67

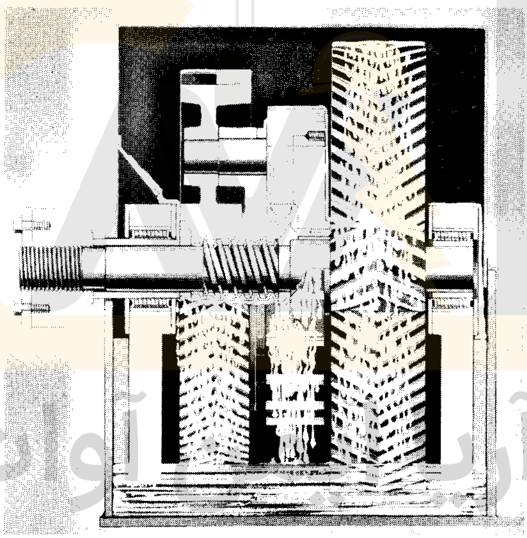


Fig. 68

friction sleeve and linkage, promptly engaging the ratchet wheel and holding it stationary. The continued turning of the brake gear backs the brake nut off the screw, thereby loosening the entire assembly and allowing the load to lower. Should the load begin to drop faster than the motor speed, the brake immediately tightens up and retards the load to conform to the motor speed. At the same time the torque of the motor is being used to keep the brake loose, resulting in an alternate tightening and loosening that occur in rapid succession. Hence, the load is lowered smoothly, without exceeding the synchronous speed of the motor.

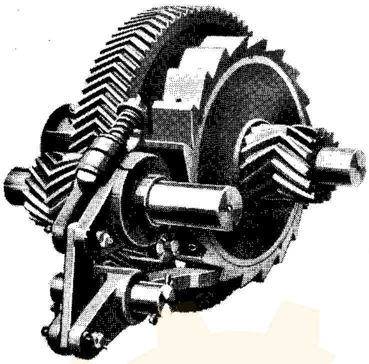


Fig. 69

Cooling of the brake is accomplished by the oil in the hoist case, which is also used to lubricate the gearing and bearings. A brake of good design may be adjusted by changing the position of the brake adjusting nut on the end of the brake shaft extending outside the hoist case housing.

SOLENOID BRAKE: A solenoid (holding) brake is mounted on the hoist motor or motor pinion shaft to bring the load to a full stop and hold it in position. This is an additional braking system to the mechanical brake on AC cranes and to dynamic braking on DC cranes. The solenoid brake is spring set with solenoid release. The brake is applied by opening the circuit to the solenoid, causing the solenoid plunger to drop, allowing the brake linkage to be actuated by the powerful brake spring. The brake always maintains a safe condition by automatically setting and holding the load, in case of power failure or accidental interruption of current.

Class E and F DC cranes of capacities over 25 tons may require a second solenoid brake mounted on the motor pinion or intermediate pinion shaft extension.

This type of brake is also used as a brake on the trolley drive or a bridge brake on floor controlled cranes.

The formula to determine the proper size brake to equal the full-load torque of a motor, when applied to the motor shaft is:

$$\text{Holding torque in pounds feet} = \frac{\text{H.P. x 5250}}{\text{R.P.M.}}$$

Figures 52 (page 77), 70 and 71 show typical installations of solenoid hoist brakes.

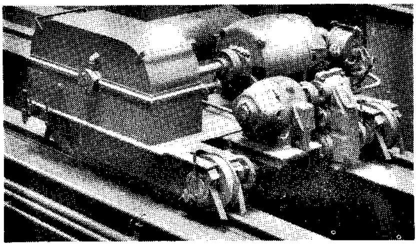


Fig. 70

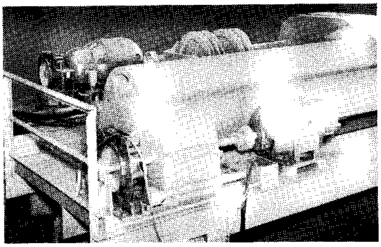


Fig. 71

Brake manufacturer's catalogs will give brake ratings and also service factors which should be used in the application of brakes to cranes of the different service classes. All hoisting brakes should always be equivalent to at least the full torque rating of the motor. Class E and F cranes may require brakes up to 200% of motor rating.

LIMIT SWITCHES: Crane trolleys are equipped with hoist limit switches to automatically stop the hook in its highest safe position. They may be of the block-operated or the screw type. The block-operated limit switch may be of the paddle type, Figure 72, or the weight type, Figure 73.

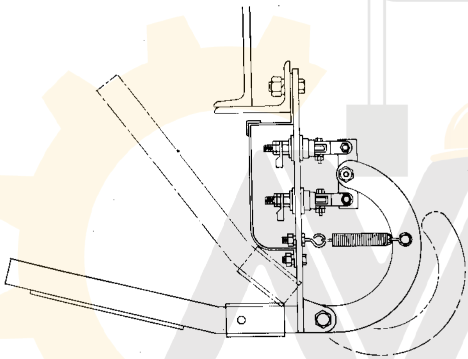


Fig. 72

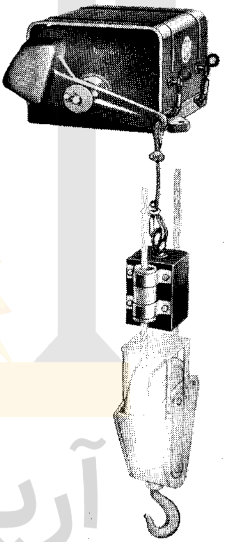


Fig. 73

In the paddle-type switch, the load block raised to its high position, hits the paddle and rotates it about its hinge point until the movement is sufficient to disengage the contacts of the "knife" part of the switch.

In the weight-operated type the load block contacts a weight suspended from the operating arm of the limit switch. Further raising this weight opens the hoisting circuit. This breaking of the circuit stops further energizing of the hoist motor.

The block however, may "drift" upward after current is interrupted. This "drifting" is a function of the speed at which the block was traveling as it hit the switch and also the weight of the block and load being hoisted and the inertia of the motor, drum and the other rotating parts. In designing and installing block-operated limit switches allowance is made for drift. In cranes with magnetic control the control circuit is opened to interrupt the current to the hoist motor.

To return a load block to within its normal lifting range, it is only necessary to move the controller to lowering position. By action of gravity and tension spring, the limit switch resets itself as the block is lowered out of the limit switch zone.

In instances where both upper and lower limits are desired, a screw-type limit switch with upper and lower limits may be used or a block-operated upper limit and screw-type lower limit could be used. Screw-type limit switches may be easily set to open the circuit at any predetermined point of the lift. They are also reset automatically by moving the controller in the opposite direction.

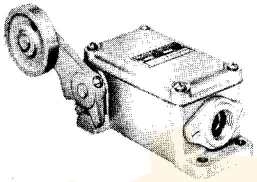


Fig. 74

Besides limit switches on hoists, limit switches are sometimes used to limit trolley or bridge travel. For these purposes, track-type limit switches, Figure 74, are used.

TROLLEY TRAVEL DRIVES: The trolley travel is accomplished by a motor or hand-power chain sprocket through gearing and cross-shaft to a driving wheel at each side of the trolley. Good design again calls for the gearing to be enclosed in an oil-tight gear case at center of trolley gauge. The slow-speed shaft of this gear case is directly connected to the wheel axles which turn on anti-friction bearings mounted in capsule housings, Figure 52, page 77.

For extremely slow trolley speeds, a geared-head motor may be used or an extra reduction of gearing inserted between the gear case and the cross-shaft axle.

In selecting the trolley drive, the weight of the trolley, (Section VI) and load to be moved and the speed with which they are to travel determine the horsepower and the reduction ratio required. The horsepower required is computed from the following formula: (See Section IX-C for a discussion of motors for trolley drives.)

$$HP = \frac{FPM \times W \times TE}{33{,}000}$$

FPM = Trolley travel speed.
W = Total weight of trolley plus load in tons.
TE = Tractive effort constant. (Range from 20 to 35 depending on speed desired, see table below.)

Trolley Speed FPM	Tractive Effort Constant
0 - 99	20
100 - 149	25
150 - 199	30
200 - 299	35

Knowing the trolley speed desired, the full load RPM of the trolley motor and the circumference of the trolley wheels, substitution in the following formula gives the ratio required in the trolley drive case:

$$\text{Ratio} = \frac{\text{RPM x C}}{\text{FPM}}$$

RPM = Full load motor RPM.
C = Circumference of trolley wheels in feet, Table 7, page 69.

Once the horsepower and ratio required in the trolley drive case are known, a suitable selection of a drive case can be made by referring to manufacturer's tables in which the horsepower rating for various trolley drive cases is given and applying the proper factor for Class of crane service. The strength of gearing may also be checked by referring to tooth load formulae found on page 87.

TROLLEY WHEELS: Trolley wheels used on cranes of 5 to 200 ton capacity vary in size from 10″ in diameter for 5 ton trolleys to 27″ in diameter for a 200 ton trolley. Intermediate sizes commonly used are 12″, 15″, 18″, 21″ and 24″ diameter. The choice of trolley wheels is influenced by the wheel load, wheel material, diameter, rail size, trolley speed desired and operating conditions. Rolled steel or forged steel wheels are however, used in most applications.

Figures 75 and 76 show typical trolley wheel bearing installations

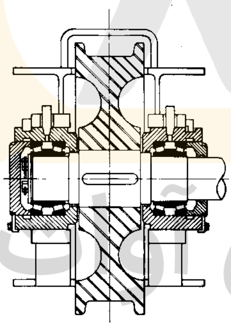


Fig. 75

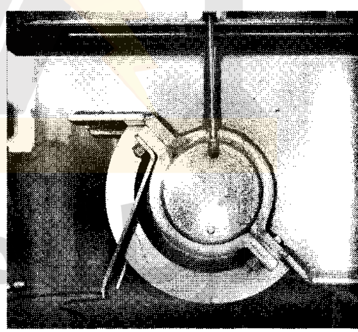


Fig. 76

for both idler and driver wheels. As can be seen in these figures each wheel rotates on two roller bearings, each mounted in a capsule housing held in place with two through bolts. This method of mounting provides firm and accurate positioning of the bearings yet allows for easy and rapid disassembly should inspection or replacement become necessary. For driver axles, flange type couplings are pressed and keyed in place.

FRAME: The trolley frame consists of the 2 trucks and the one or two load girts. Where shipping limitations do not govern, the frame should be fabricated from plates and structural shapes which are welded into a one-piece unit. If the size of the finished trolley necessitates dismantling for shipment, the load girts should be securely fastened to the trucks with turned-bolt connections. The trolley trucks and girts should be designed to have a minimum deflection under load and free use should be made of box section design.

The load girt supports the trolley drive and a large percentage of the live load as it contains the upper sheaves and the equalizer sheave of the rope reeving. Care must be taken that the load girt stresses are transmitted directly to the trolley trucks and will not affect the machinery alignment.

The trolley trucks support the load girt reactions, the hoist machinery and in most cases the drum supporting bearings. They contain the wheel and wheel bearing assemblies.

The trolley frame should be designed to resist all loading imposed by the motor, gearing and load without excessive dead weight so that the moving load may be kept to a minimum to reduce operating costs. Typical trolley frame construction is shown in Figure 77.

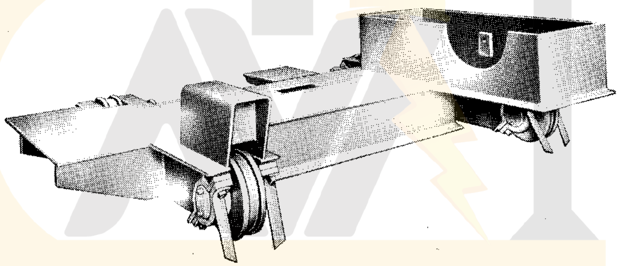


Fig. 77

COLLECTORS: In addition to the collectors detailed in Section IX-A, pages 74 and 75, the following are used for the trolley:

- Single wheel type.
- Enclosed conductor type (for fig. 42, page 74).
- Multi-conductor cables.
- Insul-8-Bar, open and sheathed (for fig. 41, page 74).

AUXILIARY HOIST: The utility of many cranes is increased by providing the trolley with an auxiliary hoist in additon to the main hoist. There are occasions where loads of considerably less weight than the rated capacity of the main hoist must be lifted. To lift these loads is the function of the auxiliary hoist. Since the rated capacity of an auxiliary hoist is only about 15% to 25% of the main hoist, hoisting speeds can be considerably faster and still use a much smaller hoisting motor. These loads, within the capacity of the auxiliary hoist, can thus be hoisted faster and at less cost than if the main hoist were used.

Since the only difference between the main hoist and the auxiliary hoist is a quantitative one, the previous discussions covering load blocks, wire rope, drums, hoist cases, solenoid brakes and limit switches apply equally well to auxiliary hoists. See Figures 78 and 79 showing trolleys equipped with auxiliary hoists.

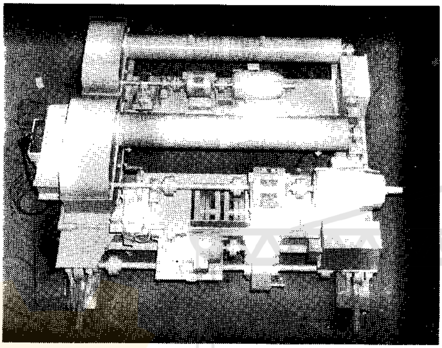


Fig. 78

Fig. 79

In specifying cranes, particularly in the larger capacities, it is well to consider the advantages obtained by choosing cranes with auxiliary hoists. The additional usefulness and operating economy of such a crane may well justify the additional original cost.

By taking advantage of certain types of electrical control, it is possible to obtain higher speeds for no-load and light-load conditions which result in the operating characteristics of a main and auxiliary hoist with only the main hoist mechanical equipment. With only one hook on the trolley, better floor coverage is possible for handling the capacity loads of the crane. Light-load speeds from 2 to 3½ times the rated load speeds are possible.

PART C — ELECTRICAL EQUIPMENT

This part of the Crane Design Section will cover power sources, motors, brakes, control, resistors, protective equipment, limit switches, wiring and control arrangements. This equipment is a vital component of every crane. Other electrical equipment will be treated as accessories in Sections XI and XIII. Because electrical equipment is available from many sources, it is recommended that the make, type and rating of this equipment be determined by the crane manufacturer after the service requirements have been thoroughly studied.

POWER SOURCES: For crane operation, two kinds of electrical energy are available, direct current and alternating current in various voltages and frequencies. The service classification of the crane and the power available in the local area determine to a great degree which current shall be used.

ALTERNATING CURRENT: Alternating current is one that flows first in one direction and then in the opposite direction at regular periodic frequencies or pulsations. It is far more popular than direct current in this country. The ease and economy with which alternating current can be distributed, accounts in part for its preference as a power source in both domestic and industrial applications. Although single phase, 60 cycle, 110 volt current is most popular in domestic use, the current most frequently provided industrial users in 3 phase, 60 cycle, 440 volt current. 220 volt and 550 volt, 3 phase, 60 cycle current for industrial use follow in popularity in that order. Where both 440 or 220 volt current are equally available, the 440 volt current should be chosen for crane service for economic reasons. With 440 volt AC current, wiring, starters, contactors, switches, controllers, resistors and other components of a crane's electrical system can be kept to a minimum size with lower initial cost and maintenance expense. Another variation in alternating current besides phase and voltage is the cycle characteristic of the current. Other than the popular 60 cycle current 25 and 50 cycle current is also used.

DIRECT CURRENT: Direct current is one that flows continuously in the same direction. Cranes powered by direct current motors are usually limited to those installations where direct current is generated because of its convenience or necessity in a manufacturing process. 230 volts is the more frequently used voltage where DC current is used. 550 volt DC however, is used to a limited extent. A point in favor of DC is that hook without load can be raised at about 200% of full load speed and fractional loads at more than full load speed, and if dynamic braking is used, the wear of mechanical load brake parts is eliminated. In those installations where both AC and DC current are available, AC current would be preferred for economic reasons as the power source of an electrically operated crane.

INDEPENDENT POWER SYSTEMS: There are crane installations, usually gantry cranes, where it may be advantageous or necessary for a crane to be provided with a self-contained electric power source. These installations are provided with either gas- or diesel-powered engine generators and would be specified under the following conditions:

1. Unavailability of other suitable power source.
2. Extensive length of runway that would make electrification costly and current loss excessive.
3. Frequent adverse weather conditions, such as ice or sleet formation, that would make current collection from outside runway conductors difficult.
4. Emergency power in case of failure of outside source and the necessity of continued operation of the crane.

CURRENT REQUIREMENTS FOR CRANES: In a new crane installation or the addition of more cranes on an existing runway, the size of runway conductors and power wires must be determined or checked. The power requirements in horsepower or kilowatts may be found from the following power formulae and the ampere rating of motors given in Table 16. Use only the sum of the largest motor plus 50 per cent of the next larger motor, for the total horsepower.

Line Input Power Formula — Direct Current (DC) $W = VA$

Alternating current (AC) 3 phase $W = 1.73\ VAP_f$

W = power in watts

V = volts

A = current in amperes

P_f = power factor, usually .80 at full load

1-KW = 1000 watts = 1.34 horsepower

1-HP = 746 watts = .746 Kilowatts

Table 16 — ALTERNATING CURRENT — 3 Phase — AISE Mill Motors

		One hour rating			
		H.P. @ 440 Volts		Amperes @ 440 V.	
Frame	RPM	85°C TENV.	80°C PSV	Secondary	Primary
AC-1	1200	5	6.25	19	8.2
AC-2	1200	10	12.5	26.5	15
AC-4	1200	20	25	38	30
AC-8	1200	40	50	75	55
AC-12	1200	60	75	92	76
AC-18	900	90	112	162	148.5
AC-25	900	125	156	190	172
AC-30	900	150	188	207	215
AC-40	720	200	250	365	291
AC-50	720	250	312	402	365

Table 16 (Cont'd) — ALTERNATING CURRENT — 3 Phase — Wound Rotor

Output H.P.	RPM	220 Volts	440 Volts	H.P.	RPM	220 Volts	440 Volts	H.P.	RPM	220 Volts	440 Volts
1	1200	4.0	2.0	10	1200	29	15	50	1200	129	65
	900	5.0	2.5		900	35	18		900	138	69
									600	154	77
1½	1200	7.0	3.5	15	1200	43	22	60	1200	154	77
	900	8.0	4.0		900	52	26		900	166	83
									600	168	84
2	1200	8.0	4.0	20	1200	56	28	75	1200	192	96
	900	10.0	5.0		900	63	32		900	208	104
					720	75	38		600	221	111
3	1200	12.0	6.0	25	1200	68	34	100	1200	246	123
	900	13.0	6.5		900	82	41		900	254	127
					720	85	43		600	285	143
5	1200	18.0	9.0	30	1200	82	41				
	900	20.0	10.0		900	93	47	125	600	355	178
					720	84	42				
7½	1200	24	12	40	1200	106	53	150	600	395	198
	900	27	13.5		900	116	58				
					720	111	56	200	600	500	250

Table 16 (Cont'd) — DIRECT CURRENT — Series Wound — Solid Frame

Output H.P.	230 Volts	550 Volts	H.P.	230 Volts	550 Volts	H.P.	230 Volts	550 Volts
2	8.3	3.4	25	92	38	60	215	90
3	12.3	5.0	30	110	45	75	268	111
4	16.1	6.6	35	128	53	90	322	132
5	20	8.2	40	146	61	100	357	146
7½	29	12.0	45	163	68	125	443	184
10	38	16.0	50	180	75	150	528	220
12½	47	19.5				175	617	257
15	56	23				200	705	295
20	74	30						

Table 16 (Cont'd) — DIRECT CURRENT — 230 volts — AISE Mill Motors — Series Wound

FRAME NUMBER 1949	1940	One Hour rating H.P.	AMP	½ Hour rating H.P.	AMP
2	2	5	21	6½	29
602	3	7½	31	10	44
603	4	10	40	13½	57
604	6	15	57	19	77
606	8	25	95	33	126
608	10	35	132	45	175
610	12	50	185	65	245
612	14	75	272	100	368
614	16	100	360	135	500
616	18	150	540	200	740
618	—	200	730	265	900
620	—	275	975	360	1314
622	—	375	1370	500	1830
624	—	500	1830	660	2400

Table 16 (Cont'd) — DIRECT CURRENT — 230 Volts — Armored Mill Motor — Series Wound

FRAME	60 Min. 75°C Rise H.P.	60 Min. 75°C Rise AMP	30 Min. 75°C Rise H.P.	30 Min. 75°C Rise AMP
802A	5	21	6½	29
802B	7½	31	10	44
802C	10	40	13½	57
803	15	57	19	77
804	20	76	26	100
806	30	114	39	151
808	50	185	65	245
810	70	260	90	330
812	100	360	135	500
814	150	540	200	740
816	200	730	265	900
818	250	920	325	1190
620	275	975	360	1314
622	375	1370	500	1830
624	500	1830	660	2400

The above tables are average and may vary slightly depending upon the motor manufacturer.

MOTORS

Two types of alternating current (AC) motors, squirrel cage and wound rotor and two types of direct current (DC) motors, series wound and compound wound are employed for crane service.

AC MOTORS — SQUIRREL CAGE TYPE: Squirrel cage motors are designed for intermittent service where frequent starts, stops, and reversals are encountered; where high inertia loads must be accelerated; and where no speed control is required. They have high starting torque, low starting current, and high slip at full load. Lack of speed control may be overcome by using a two-speed, two winding motor to give operating speeds of full and one-half rated speed. This two-winding construction is not a stock condition with most motor manufacturers and therefore price and availability are adversely affected. The use of squirrel cage motors to power crane hoists is limited in practice to those applications requiring only one or two hoisting speeds and requiring usually not more than 10 horsepower. Resistance is sometimes used in the primary winding to give slow starting, but this is not as effective in speed control as the use of the slip-ring motor.

FLUID DRIVE MOTORS: As a power source for both crane bridge and trolley drives, squirrel cage motors can be used with fluid couplings to provide satisfactory single speed operation. Several companies manufacture fluid drive motors in which a squirrel cage motor and fluid coupling are combined as a unit. In operation the motor starts under no-load and comes up to about 85% of full speed before starting the load. This no-load starting results in savings in electric power demand cost because of low starting current. In addition to the economy of operation, fluid drives provide positive but gradual acceleration up to operating speed.

Squirrel cage motors hold a limited position of usefulness as a motive source on cranes. When selected for suitable applications, low cost, satisfactory operation and low maintenance are the usual result.

AC MOTORS — WOUND ROTOR TYPE: The majority of cranes using alternating current power use motors of the wound rotor (slip ring) induction type, Figure 80. The particular characteristic of the wound rotor motor that makes it well suited for crane use is the fact that speed control can be accomplished from zero to synchronous speed by means of controller and resistance. Used with light loads or no load it does not speed up beyond its synchronous speed. This type of motor stalls at about 275% torque, thereby preventing extreme overloads on the crane.

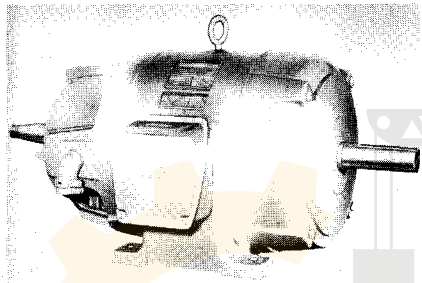


Fig. 80

The speed of a wound rotor motor is dependent on the number of poles in its stator winding and the cycles of the power supply current. 1200 and 900 RPM motors are most frequently used as crane motors so that economical gear cases may be used without the necessity of extra reductions. When under full load, these motors develop a "slip" of approximately 5 to 10% varying inversely as the square of the applied voltage. It is important to provide full voltage at the motor, as the torque varies in the same ratio as the square of the voltage. A 10% voltage reduction means a 19% torque reduction.

Resistors connected in series with the armature or secondary circuit provide high resistance when starting a wound rotor motor. This reduces the current demand in starting yet provides high starting torque to start the load in motion. Further reduction of resistance in the secondary circuit increases the motor speed. Choice of motor controllers and resistors provides control over the operating characteristics of wound rotor motors. For example, the rate of motor speed and the number of speed points are directly influenced by choice of controller and resistors. Further discussion on this subject of controlling a wound rotor motor will be found in the discussion of crane control starting on page 108.

AC MOTORS — AISE MILL MOTORS: The use of AC current in the steel-making industries has necessitated the design and manufacture of a new line of motors meeting the AISE specifications. These motors meet the AISE Standard 1-A and provide shock-resistant frames, heavy-duty mounting pads, oversized shafts and heavy-duty, specially braced Class F insulation. Breakdown torque is not less than 325% of its one hour rating. The maximum allowable speed is 200% of its rated RPM. Features of control are the same as described in the previous item of wound rotor motors. This motor is illustrated in Figure 81.

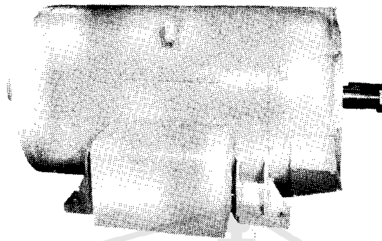


Fig. 81

DC MOTORS — SERIES WOUND TYPE: In crane installations using DC power the series motor, Figure 82 solid frame, Figure 83 mill, is usually used. Split frame motors, Figure 84, are no longer manufactured and are replaced in crane use by the solid frame or mill type motors. These motors develop very high starting torque and can rapidly accelerate heavy loads. They handle overloads far above

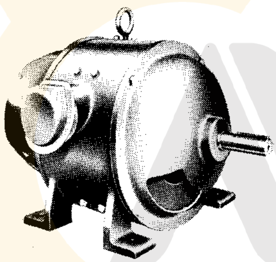


Fig 82

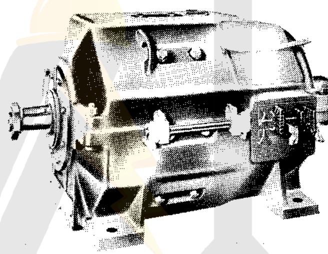


Fig. 83

their full capacity. Speed control over a wide range of speed is accomplished by varying the amount of resistance connected to the armature and field. The speed of a series motor varies greatly when the load is varied, that is, at a given speed point on the controller, the speed while handling a light load will be considerably higher than when handling a capacity load. This characteristic, although it at first may sound objectionable, does possess the advantage that under most operating conditions it is safe and time-saving for a crane to lift or travel at a faster speed when operating with no load or only handling a light load when compared to its speed with a heavy load.

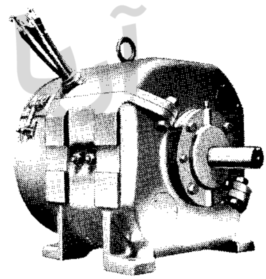


Fig. 84

The use of slower speed motors for the hoist is recommended so that run-away speeds with light loads will not result, in actual operation. Faster speed motors may be used for trolley and bridge travel as the dead load to be moved is always a large part of the total load and not as adversely affected by speed-up as the hoist motion.

DC MOTORS — COMPOUND WOUND TYPE: These motors are used on cranes only when it is necessary to limit the no-load speeds of each motion. This motor is similar to a series wound motor in construction and characteristics, except that the compound winding on the field prevents its no-load speed from exceeding 150% of full load speed.

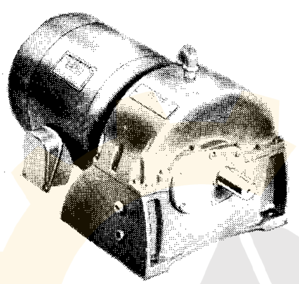


Fig. 85

GEAR MOTORS: In all typical applications of electric motors for crane use, the output speed of the motor is greatly reduced by gear units before actual connection to the load. Gear motors or motor reducers, Figure 85, that combine a motor and gear case in a single unit are available in different horsepower ratings and output speeds in various types of either AC or DC motors. Gear motors find limited use in crane design, usually in trolley or bridge travel drives where an extremely slow operating speed might be required.

MOTOR RATINGS: In addition to meeting design problems concerning structural strength and electrical theory, electric motors must be built to with-stand the temperature rise that occurs in running a motor. This heat produced in an electric motor is of both electrical and mechanical origin. To keep motors operating within safe temperature limits, motors are given a horsepower rating with a specified limit on the motor temperature rise. An alternating current wound rotor type motor, for example, might be rated at 10 horsepower — continuous 40° centigrade. This means that the motor can deliver 10 horsepower at rated RPM continuously and not exceed 40° centigrade temperature rise above ambient temperature assuming that ambient temperature is not above 40°centigrade.

SHORT TIME RATED MOTORS: In most crane applications the motors are never in continuous operation and need not have a continuous rating. To meet the need for motors to operate at less than continuous duty, motor manufacturers offer short-time rated motors.

Motor frame sizes are determined by the time rating, the insulation, and the allowable temperature rise of the motor in the prescribed service in which the motor is used.

Time and temperature ratings are as follows:

AC Motors — Squirrel cage, same as wound rotor.
— Wound rotor, open - 15, 30 and 60 minute 70°
— Wound rotor, enclosed - 30 and 60 minute 75°

AC Motors — Mill-Type - Open - 60′ 80° C
Mill-Type — Totally encl. non-vent. - 60′ 85° C
DC Motors — Series, solid frame - 15, 30, and 60′ 75° C
— Series, Mill-Type - 30 and 60 minute 75° C

For a standby service crane a 15 minute rated motor would no doubt be adequate. A bucket handling crane, however, may require a 60 minute rated motor. Where there is doubt as to whether a motor is adequate for applications involving a severe duty cycle, a detailed analysis of the duty cycle should be made, see Section V. Calculations made by the motor manufacturers should be used to determine motor horsepower requirement in these instances. General recommendations for each class of service is given in Table 17.

Table 17 — Recommended Motor Ratings

Service Class	Hoist	Bridge & Trolley	Motor Insulation AC	Motor Insulation DC
A	Short lift, 15 min.	15 min.	A, B	B
	Long lift, 30 min.	15 min.	B	B
B	30 min.	30 min.	B	B
C	30 min.	30 min.	B	B
D	No cycle, 30 min.	30 min.	B	B
E	With cycle, 60 min.	60 min.	B, F	B, H
F	60 min.	60 min.	F	H

In Class E and F consideration must be given to enclosed motors for atmospheric condition.

Formulae for horsepower calculations have been given under bridge, hoist and trolley travel design, Section IX, A and B.

Motor rating will be affected if the ambient temperature is above 40° C. and if the altitude is greater than 3300 ft. above sea level.

MECHANICAL FEATURES OF MOTORS

MOTOR ENCLOSURES: Among the mechanical features of electric motors the National Electrical Manufacturers Association (NEMA) lists four basic type motor enclosures; open, totally enclosed, shell and hermetic. There are numerous specific types listed under the open and totally enclosed classification. For crane application, however, the usual installation is provided with either an open dripproof motor or a totally enclosed nonventilated motor. There are crane installations where explosion-proof motors might be required. Fan-cooled motors add to the cost, and for crane duty the fan is not running enough at sufficient speed to be effective. It is very important that where special or unusual operating conditions exist that the details be provided to the crane manufacturer so that motors designed to operate in these special conditions can be provided.

MOTOR INSULATION: The type of insulation used in a motor is another mechanical feature that can be chosen to suit the conditions under which a motor will operate. Insulation for motors is generally classified into four groups: Class A, Class B, Class F, and Class H. Class A insulation rated 50° C. rise, includes the organic materials; Class B insulation, rated 75° C. rise, includes the inorganic materials such as mica and asbestos; Class F insulation, rated 100° C rise, includes the silicones and fiberglass; Class H insulation, rated 120° C. rise, includes the higher grades of silicones and fiberglass. Class B insulation is furnished for most crane motor installations, but there are, for example, applications where excessive temperature, humidity, fungus or corrosive atmosphere might dictate the choice of a more suitable insulation. See Table 17 for general recommendations.

MOTOR SHAFTS & MOUNTINGS: There are other mechanical features of motors such as shaft style, type of motor mounting, etc. The choice of these features should be left to the crane manufacturer, so that these units will fit into his standard construction.

ELECTRIC BRAKES

Electric brakes are used on cranes as a holding brake on the hoist motor, as a bridge brake on floor controlled cranes or occasionally as a travel brake on the trolley. Mechanically, the types of brakes usually used could be defined as either of the shoe or disc type. Brake linings should be materials which provide a high coefficient of friction, are heat resisting, and will provide long life. Wheels should be of material that does not readily score and of sufficient diameter and face to provide low braking pressures. Describing these holding brakes electrically, they would fall into the following classifications: 1. Solenoid Type, 2. Thrustor Type, and 3. Magnetic Type.

SOLENOID BRAKE: Figure 34, page 71, shows a typical solenoid brake. As is common with all of the electric brakes shown here, this brake is spring set and is released when the solenoid is energized. By means of a linkage arrangement, the spring pressure is overcome by the solenoid and the brake shoes are pulled back from contact with the brake wheel. Refer to Table 18 for available sizes and ratings of solenoid brakes.

Table 18 — Solenoid Brake Ratings — Lb. - Ft.

Size	Max. Torque Intermittent	Face Width	Size	Max. Torque Intermittent	Face Width
4″	15	$2\frac{3}{4}$″	8″	140	$3\frac{3}{4}$″
$5\frac{1}{2}$″	35	$3\frac{1}{4}$″	10″	200	$4\frac{1}{4}$″
6″	55	3″	12″	300	$4\frac{1}{4}$″
7″	75	$3\frac{1}{8}$″	15″	550	$6\frac{1}{8}$″

A refinement of the solenoid brake has been developed and is shown in Figure 86. This brake has the solenoid encapsulated in an oil bath which reduces the pounding action of the solenoid and contributes to longer life of the solenoid and reduced wear on the brake linkage due to heavy impacts. Another feature of this brake is the addition of a self-adjusting mechanism which automatically compensates for lining wear and retains the gap between lining and face of brake wheel at the desired operating range; this feature reduces maintenance by eliminating manual adjustment and reducing impact at the solenoid. Sizes and ratings of this brake are given in Table 19.

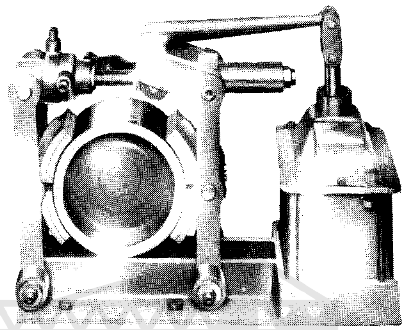


Fig. 86

Table 19 — Self-Adjusting Solenoid Brake Ratings — Lb. - Ft.

Size	Max. Torque Intermittent	Face Width
8	140	3¼″
10	200	3¾″
13	550	5¾″

THRUSTOR BRAKE: Figure 87 shows a typical thrustor type brake. This brake is spring set and is held in released position by hydraulic pressure opposing the spring. This hydraulic pressure is developed by a small electric motor driving a centrifugal impeller forcing oil in a hydraulic cylinder against a piston. In some thrustor brakes a delay action in the setting of the brake is provided by means of a valve in the hydraulic circuit. This brake is primarily used on AC current. Refer to Table 20 for available sizes and ratings of this brake.

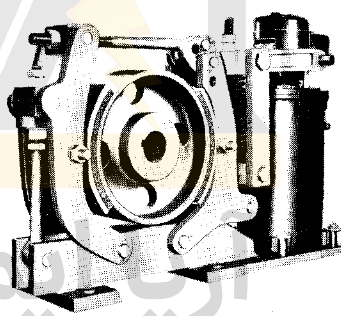


Fig. 87

Table 20 — Thrustor Brake Ratings — Lb.Ft.

Wheel	Cont. Rating	1 Hour Rating	Face	Wheel	1 Hour Rating	½ Hour Rating	Face
8	125	160	3½	8	125	160	3⅛
11	325	400	5	10	325	400	5¼
14	600	800	6½	13	600	600	5¼
19	1200	1600	8	16	600	800	7¼
24	2400	3600	10	19	1200	1600	8¼
				23	2400	3200	9¼
				28	6000	6000	11¼

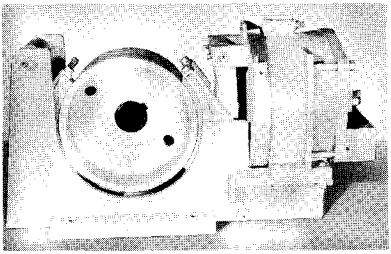


Fig. 88

MAGNETIC BRAKE: Figure 88 shows a typical magnetic brake. Here again the brake is spring set and held in released position by magnetic action. With DC current supply this brake is series wound and at ½ hour rating, the brake is released at 40% full load motor current and remains released on 10% full load motor current. With AC current supply this brake is shunt wound and requires a rectifier for its operation. Sizes and ratings of this brake are given in Table 21.

Table 21 — Magnetic Brake Ratings — Series or Shunt in Lb. Ft.

Size	Max. Torque Intermittent	Face	Size	Max. Torque Intermittent	Face
4½	25	3⅛″	16	1000	6¾″
6	50	3⅛″	19	2000	8¾″
8	100	3¼″	23	4000	11¼″
10	200	3¾″	30	9000	14½″
13	550	5¾″			

SHOE & DISC BRAKES: Figures 34, 86, 87 and 88 are all brakes of the shoe type. Electrical brakes of the disc type are quite satisfactory, but their use is usually limited to brake motors, those installations where the brake is designed as a component or accessory part of the motor, with 15 H.P. maximum. A typical brake motor is shown in Figure 89.

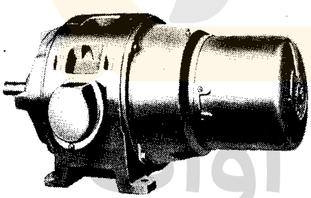


Fig. 89

Two other types of electric brakes, one used exclusively as a controlling brake and the other as both a controlling and holding brake should be given consideration.

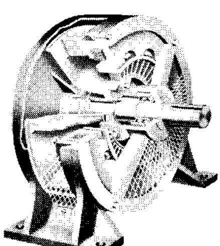


Fig. 90

The Eddy-Current brake, a speed controlling device, is used in place of mechanical load brakes or other electrical means of braking on cranes using wound rotor motors. The brake holds the speed and load without friction, and at selected speeds, in accordance with the controller position. This brake stabilizes and loads the wound rotor motor to such an extent that smooth lowering and hoisting speeds can be maintained regardless of load on the hook. A complete unit mounted on its own bearings for connecting to a motor shaft with a flexible coupling is shown in Fig. 90. Brake ratings are given in Table 22.

Table 22 — Eddy Current Brake Ratings

Model Brake	Operating Speeds		Max. Torque in Lb.Ft.	
	Normal	Maximum	1200 RPM	900 RPM
AB-701	3600 RPM	6000 RPM	5.5	5.0
AB-702	"	"	27	24
AB-703	1800 RPM	4400 RPM	49	43
AB-704	"	"	99	90
AB-705	1200 RPM	2000 RPM	204	195
AB-706	"	"	410	388
AB-707	900 RPM	2000 RPM	870	870
AB-708	"	"	1740	1740
AB-709	720 RPM	1500 RPM	2100	2100

The Adjustable Torque brake is a fail-safe, spring-set brake used as a parking brake for bridge or trolley motions and as a controlling brake for applying braking torque to the bridge or trolley motions by controlling the spring tension thru a foot-switch or pushbutton operated coil in three steps of intensity. This brake is well adapted to the bridge motion of floor- and remote-operated cranes and for controlling the bridge braking when the cab is mounted on the trolley. Refer to Table 23 for operating speeds and torque values for the available brake sizes.

Table 23 — Adjustable Torque Brake Ratings. Lb.Ft.

Size	Max. Parking Torque	Normal Adj. Torque	Maximum Adj. Torque
10″	200	200	400
13″	550	550	1100
16″	1000	1000	1500

BRAKE RATINGS: Proper selection of an electric brake is made by computing the torque required (Torque in lbs. ft. $= \frac{\text{H.P.} \times 5250}{\text{RPM}}$ and then selecting a brake of equal or greater torque rating to be mounted on the shaft of the RPM designated in the above formula. Electric brake torque ratings are usually listed with both a continuous and intermittent rating. The service class of a crane must be considered before proper selection of an electric brake can be made. Use Table 17, page 103, so that brake rating corresponds to motor rating shown. Brake ratings are shown in Tables 18, 19, 20, 21, 22 and 23.

CRANE CONTROL

The satisfactory performance of a crane is dependent to a great extent upon the selection of the proper control for each motion. This selection cannot be made from any formulae, but must represent the experience and judgment of the crane builder. It may be influenced by the type of service, severity of duty, size and type of loads, operating speeds, the degree of precision required, safety requirements, and the buying habits of the purchaser.

Crane control is divided into four types according to design: Manual, semi-magnetic, magnetic and static; and into four categories according to operation: Cab, floor, remote and automatic. We will consider the manual, semi-magnetic and the DC magnetic as general crane controls for all motions and divide the AC controls into (1) hoist and (2) bridge and trolley motions.

MANUAL CONTROL: The previously popular drum controller has become almost obsolete and is manufactured only by a few electrical companies today. Many drum controllers are still in use so that a description of this control is in order.

The controller itself consists of a set of stationary fingers and movable contacts that engage first to complete the electrical circuit and then cut the resistance out of the circuit as the handle is moved either forward or reverse to regulate the motor speed. The full motor current is handled through the contacts and fingers. This system of control is used for wound-rotor AC and series-wound DC motors. From 4 to 9 points of speed regulation are available.

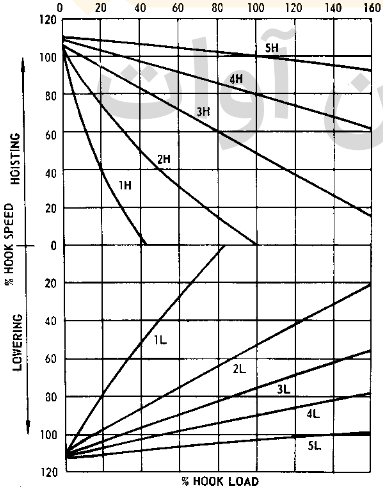


Fig. 91

With this control for AC hoists both a solenoid brake and an automatic mechanical load brake or eddy-current brake may be provided. The solenoid brake is intended to stop the motor and only sets when motor current is off. The mechanical brake, however, automatically acts in lowering a load, controlling speed of descent to conform to motor speed. Figure 91 shows the speed-load performance curves for the above control.

When used on cab-controlled cranes, drum controls with either horizontal handle, Figure 92, or vertical handle, Figure 93, can be provided. In operating either type, the

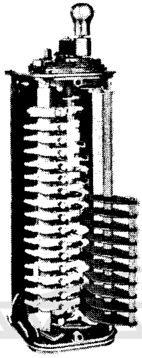


Fig. 92

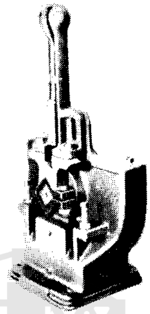


Fig. 93

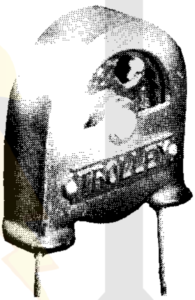


Fig. 94

crane operator would be in a standing position. When drum controllers, Figure 94, are used on floor-controlled cranes the controllers are rope operated and are equipped with spring return wheels. The fundamental advantage of drum control is its low initial cost. The disadvantages of drum control include bulky size of controllers, frequent maintenance required on controller parts, necessity of standing position required of crane operator, high physical effort required in operating the large size controllers, full voltage current in the cab, and the possibility of electrical failure if controllers are improperly used.

Drum controllers may be used to 60 H.P. at 440 volts AC and 50 H.P. at 230 volts DC. For low maintenance, the drum controller is dependent upon proper manual operation by the operator. He should make momentary stops at each control point to keep down the peak currents required by the motor to develop the high torque at low speeds. The acceleration of each motion is under the direct control of the operator and if abused, may result in motor winding burn-out.

SEMI-MAGNETIC CONTROL: With large AC motors and with a moderate duty cycle, not enough to justify full magnetic control, a semi-magnetic control may be specified. This control consists of a standard drum with fingers for operating magnetic contactors which control the motor primary circuit and contacts for handling the motor secondary circuits in the drum. The circuit is opened and closed by the contactor on the first controller point in either direction. Acceleration, deceleration, and speed changes are made by movement of the handle by the crane operator. This control may be used for cab and floor operation as described under manual control. This type of control is more expensive than manual drum, but less expensive than full magnetic. The performance is the same as shown in Figure 91.

MAGNETIC CONTROLS — GENERAL DESCRIPTION: Magnetic control is in popular use for all classes of cranes and especially in classes D, E, and F where we find large motors and cycle or heavy duty operations. It serves as a protection for the motors and as a convenience and saving of energy for the crane operator.

This system consists of master switches for cab-control, push-button stations for floor-control, control panels and resistors. The panels and resistors are usually mounted on the crane footwalk as near the cab as possible. Control panels may be open or enclosed in steel cabinets to take care of moisture, dust, or gas conditions in the crane operating area.

Acceleration and deceleration is performed automatically, when the operator moves the master-switch or push-button from neutral to either the forward or reverse position, by a combination of magnetically operated contactors and time or current relays which are brought into action. The operator starts, stops, or reverses the motion but he cannot exceed the rate of acceleration as determined by relays on the higher speed-points, thereby automatically protecting the motor against abuse by excessive current.

Each control panel is operated by a master switch or push-button which usually provides 5 speed points for hoist and 3 to 5 points for trolley and bridge travel. Crane duty resistors, commonly used, provide 50% torque on the first point. Succeeding points cut out resistance in equal steps from the 50% torque to the maximum torque of the motor.

For bridge and trolley travel motions, magnetic control of the reversing plugging type is used. For hoisting, there are many circuits and combinations which can be used. A description and performance speed-load curve will be given for each type.

MAGNETIC CONTROL — SQUIRREL CAGE MOTORS: For Class A and B cranes of light capacity, single-speed control is used where speed regulation is not essential. This control provides one speed in each direction. Fluid drive squirrel cage motors for bridge and trolley motion permit gradual acceleration to operating speed. Single speed hoisting or dual speed, in the case of a two-speed hoist motor, is available. Control of all three motions is accomplished either by a push-button station for floor control or master switches for cab control. The hoist is equipped with both solenoid and automatic mechanical load brake. No resistors are required as motors are started across the line. This control is usually limited to 10 H.P. motors maximum.

DC DYNAMIC BRAKING: This control is designed for series wound motors only, to provide safe and rapid handling of loads. It is usually used in steel mills or other rugged duty applications where severity of service and large-sized motors are found. Because of the speeding-up characteristic of series wound motors, normal speeds are maintained with rated loads but high speeds are obtained with no load or light load conditions. All points of control are not available over the load range as the heavy loads will not move on the first steps of control. The series motor is connected and controlled in the usual way for hoisting. In lowering, the series field is connected across the line in parallel with the armature causing the motor to function as a shunt-wound machine, or as a self-excited generator which produces a braking action known as dynamic braking. Besides dynamic braking all DC cranes would also be equipped with one or more magnetic brakes. These magnetic brakes, however, would not be used to control lowering speed, but only to stop the motor and hold the load when current to the motor is cut. Figure 95 shows the speed-load curves produced by this type of control. These controls are contactor reversing, contactor and resistor torque controlled, and depend on inching and jogging for load spotting. Speed control is stepped and controlled directly from the master switch. The motor is protected by timers to limit the current in acceleration and deceleration regardless of the speed in which the operator moves the master switch through the speed control points. This control is primarily used for the hoist motion and is usually without mechanical load brake. It is also used for bridge and trolley motions when the travel speeds are high and fast starts and stops are required to meet an operating cycle.

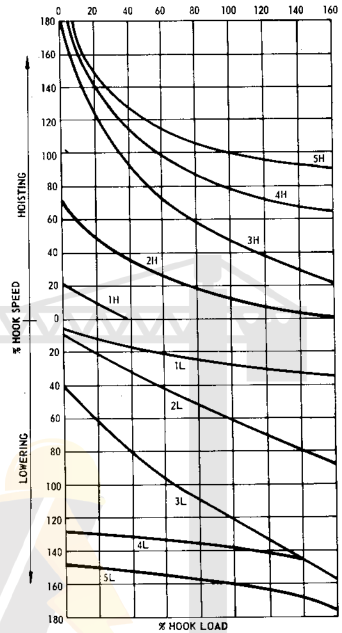


Fig. 95

DC REVERSING — PLUGGING: These controls are designed for use with either series or compound wound motors on bridge and trolley travel and series wound motors only for hoists. They provide adjustable automatic acceleration, reversing plugging control operated by 3, 4 and 5 point masters. The plugging relay prevents excessive motor current by limiting the reverse flow of current to that permitted on the first point or not to exceed that which would cause undue stresses. These controls are contactor reversing, resistor torque controlled, stepped speed control directly from the master switch and use plugging of the motor as the braking feature. Automatic or torque-controlled electric brakes or hydraulically-operated brakes are used when this control is used for bridge and trolley motions. This control is seldom used for the hoist motion.

AC MAGNETIC CONTROLS — HOIST.

REVERSING — WOUND ROTOR MOTOR — MECHANICAL BRAKE:

This is the least expensive of the many magnetic controls for the hoist motion. It is used for Class A, B, C and D cranes and is unusually well suited for powerhouses, pumping stations, substations, transfer points, machine shops, foundries, railroad shops, and manufacturing plants where service is not too severe.

The low torque on the first hoisting point makes provision for taking up slack cable and raising light loads. With the mechanical load brake, the heavy loads are held from making a downward movement when the master is set for hoisting. The hoisting points provide good speed control for normal loads. In lowering, the motor must drive against the mechanical brake in order to lower the load. Good inching or jogging performance is obtained with this control. Performance curves are shown in Figure 91, page 108.

Under this control heading we are taking the liberty of inserting a plug for our own crane control system which is described as follows:

WHITING MAGNETIC — WOUND ROTOR MOTORS — FIVE POINTS OF SPEED REGULATION:

Whiting magnetic control provides a modern economical, efficient means of controlling hoist motions for cranes of all service classifications. Whether the usage of a crane is as infrequent as standby service or as rugged as continuous material handling, Whiting magnetic control offers an ideal answer to the question, "What control shall we buy?". This system, applicable to either cab or floor control, is basically as follows: For cab control, a master switch is provided for each crane motion. 110 volt current used in the control circuit actuates contactors that control motor speed by controlling the resistance in the secondary circuit of the motor. A time delay between the third and fourth and the fourth and fifth speed points serve as protection against passing excessive current into the motor in starting. A solenoid brake along with an automatic mechanical load brake would usually be used with Whiting magnetic control for the hoist. For floor control, a push-button station is used instead of the master switches with cab control. Due to the cost of its electrical components Whiting magnetic control costs only slightly more than manual drum control. Advantages of Whiting magnetic control over drum control are convenience in use, easier, less fatiguing operation, unobstructed view when used with cab operation, operator can work while seated, very little electrical maintenance and greater safety because of 110 volt control circuits. The speed-load curves for hoist motion are the same as shown in Figure 91, page 108.

REVERSING — WOUND ROTOR MOTOR — COUNTER-TORQUE LOWERING: This simple system is used for Class F service for incinerator, cement plant and scrap handling cranes. It is well suited for rapid handling of bulk material by buckets and scrap material by magnets. It provides for very low motor heating. This control eliminates the need for a mechanical load brake by providing a counter-torque braking for retardation. An electrical holding brake is required.

The hoisting motion speed regulation is obtained by varying the resistance in the secondary of the motor. Moving the master handle to any position in the hoist direction will accelerate the motor automatically to the speed setting.

To lower, the motor is not energized and the brake is not released until the master handle is moved to the last lowering point at which time the motor accelerates automatically to rated lowering speed. To retard the load, the master handle is moved toward the "off" position. At this point the line contactors are reversed with all the secondary resistance inserted thus causing the motor to produce a reverse or counter torque. Further movement of the handle to the "off" position increases the value of the counter-torque at each point until the maximum value is reached on the first point lowering. Best results are obtained in lowering of loads between 50 and 100% capacity. Figure 96 shows speed-load performance curves.

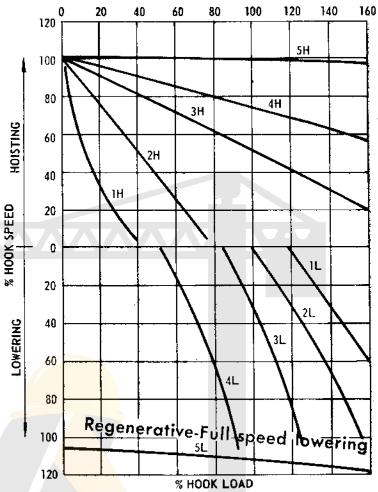


Fig. 96

REVERSING — WOUND ROTOR MOTOR — DC DYNAMIC LOWERING: This type of control is used for Class D and E service in shipyards, machine shops, and cargo handling applications where high lifts are necessary. No mechanical load brake is used. A rectifier or motor-generator set is the usual source of DC power necessary to this control system. An electrical holding brake is necessary.

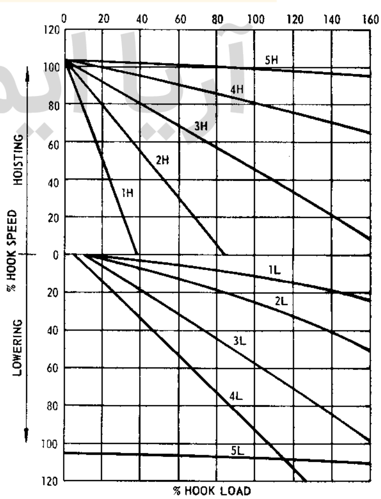


Fig. 97

The hoisting speed regulation is the same as counter-torque.

The operation for lowering is similar to counter-torque for the first step. Then as the handle is moved to the "off" position, the speeds are controlled by applying low-voltage DC power to the stator winding of the motor, while regulating the secondary resistance for the desired speed.

With this control the slowest hoisting speed is 50% for a 25% load and loads over 50% will tend to lower on the first point hoisting. Note from the speed-load curves, Figure 97, that there is a large step in lowering speed for light loads between steps 4 and 5. Also due to the way the motor is used in controlling lowering speeds, additional heating in the motor takes place. A duty-cycle analysis for the hoist motor should be made to make sure that overheating will not interfere with performance.

REVERSING — WOUND ROTOR MOTOR — SINGLE PHASE DYNAMIC LOWERING: This control is made available for installations where operation is so frequent that a mechanical load brake would develop excessive wear and cause high maintenance, and where slow lowering speeds are not required. This control can be used in manufacturing plants and warehouses where accurate spotting is required only for light loads.

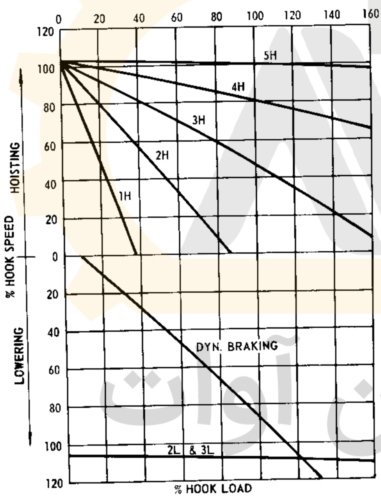


Fig. 98

The hoisting speed regulation is the same as counter torque.

The slower lowering speeds are obtained by applying a single-phase AC braking condition to the stator. Only two speeds are available, power lowering and a slow down step. The light hook will not run in the hoisting direction when the master handle is set for 1 step lowering as in the counter-torque system. This control as shown in Figure 98 should be used only where slow lowering speeds are not required for loads above 25% of rated load.

REVERSING — WOUND ROTOR MOTOR — EDDY CURRENT LOAD BRAKE: This control is designed for Class A, C., and D service for use with an electric brake of the eddy current type. It is adapted to applications requiring accurate speed control in both the hoisting and lowering directions for all conditions of loading. It finds use in assembly floor and manufacturing plant cranes.

The control system includes an eddy current brake controlled automatically or manually which provides a load on the motor at all times, permitting the excellent speed regulating properties of a loaded wound rotor motor to be utilized. For light loads on the hook, the eddy current brake provides the additional motor load so that the speeds on each point are fairly constant regardless of hook load.

The speed-load curve, Figure 99, shows the excellent control produced by this system.

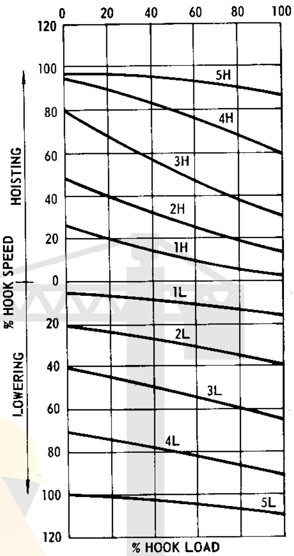


Fig. 99

REVERSING — WOUND ROTOR MOTOR — SINGLE SLOW SPEED: Where extreme precision and slow speed is required for this hoist motion, Whiting is using a wound rotor motor with the mechanical or electrical load brake in combination with a squirrel-cage reducer motor and an electric clutch. The machinery arrangement consists of a squirrel-cage motor, a speed reducer, an electric clutch, a wound rotor motor, a gear drive and a holding brake arranged in that order so that with the electric clutch in engagement the single speed squirrel-cage motor drives the hook at a constant slow speed. With the clutch disengaged the wound rotor motor drives the hook at the selected variable speeds as determined by the position of the master switch handle.

AC MAGNETIC CONTROLS — BRIDGE AND TROLLEY

REVERSING — WOUND ROTOR MOTOR — PLUGGING: This control is used on the bridge and trolley travel motions of all classes of cranes, depending upon the size of motors and accuracy of control desired. Movement of the master switch handle to the first point closes the correct directional contactors to place all starting resistance in the circuit. Accelerating points are controlled by automatic relays which cut out resistance until full speed is attained. When the master handle is quickly reversed, the directional contactors immediately reverse but the accelerating contactors are held open by the plugging relay until the motor has stopped and reversed. If an electric brake is used, a drift point should be provided so the brake relay will keep the brake released until the motor is de-energized, thereby allowing the motion to coast. As indicated, some braking is accomplished by the plugging of the motor. The controlled stopping is done with the hydraulic, electric, adjustable torque or electric-hydraulic brakes depending upon the operation of the crane, whether cab, floor or remotely operated.

AC STATIC (REACTOR) CONTROLS — GENERAL: Static electronic components are as much a part of crane controls today as the old drum controllers were years ago. The saturable reactor or transformer is the basic controlling component. The reactor is like a dry-type transformer with an iron core and A.C. power windings. The more D.C. in the core, the more A.C. to the motor until, at complete saturation, the core is virtually out of the circuit and the motor gets nearly full A.C. power.

Reactor controls present a maintenance problem which requires the learning of new techniques. The ability to spot trouble by looking at the control board to find malfunction of contactors does nothing to help where all units except the breaker for the main power circuit are static. Static controls are put up in modules and plugged into the circuit. A meter across the various terminals will reveal the malfunctioning unit, which is replaced with a new unit and the old unit may be repaired at a later time.

AC STATIC CONTROLS — HOIST: Most static control systems have primary contactor reversing means. A few systems perform the reversing function with silicon controlled rectifiers.

Torque control is obtained by saturable reactors in the primary or secondary circuit, by electric load brake, by power amplifiers which apply driving power or counter torque as required by load on the motor, or by thyristers.

Speed control may be (1) conventional stepped; (2) stepless; (3) regulated, in which the hoist handles the load at the speed called for by the master switch, regardless of load weight; (4) non-regulated, in which the load influences the speed, irrespective of position of master switch; (5) feedback signals, pilot generator or other load measuring device; (6) load float, zero speed with brakes released.

Braking is accomplished in one of the following methods, either singular or in combination: (1) Counter torque; (2) Regenerative; (3) electric holding brake, shoe or disc type, solenoid or rectified D.C.; (4) Eddy current load brake; (5) mechanical load brake.

Performance diagrams for these controls may vary slightly for the different manufacturers but all will

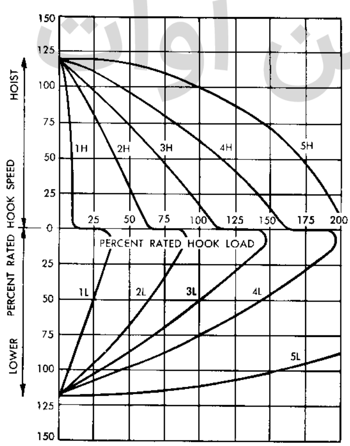


Fig. 100

approximate the stepped performance, figure 100; and the stepless as shown in figure 101.

AC STATIC CONTROLS — BRIDGE AND TROLLEY: The reversing means are: primary contactors, primary reactors, or amplifiers and resistors in the secondary.

Torque control is obtained with primary or secondary saturable reactors or with thyristers.

Speed control is stepped or stepless and may be regulated or non-regulated.

Braking is plugging, countertorque and plugging, regenerative, plus holding electric brakes, hydraulic, or electric-hydraulic.

Performance diagrams for these controls are shown in Figure 102 for stepped performance and Figure 103 for stepless.

ADJUSTABLE VOLTAGE D.C.: These drives provide precise control and excellent characteristics. They require fewer conductors, installation is simple, power consumption is low and economical. Regenerative braking puts power back into the A.C. line. Because of fast empty hook speed, one hoist may take the place of main and auxiliary hoists without sacrificing

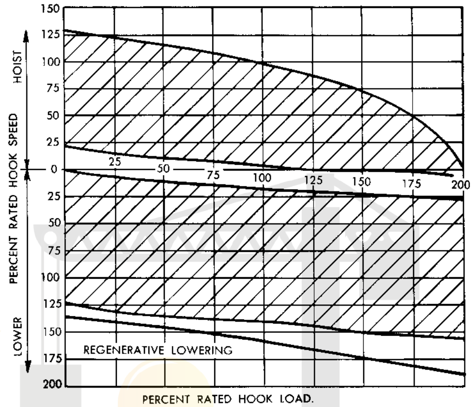


Fig. 101

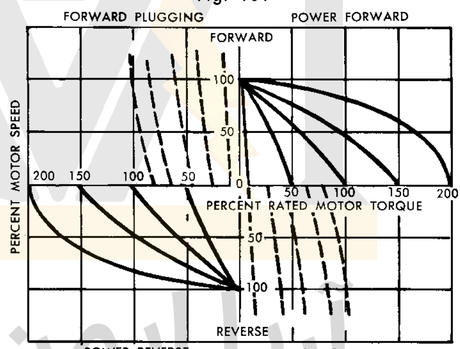


Fig. 102

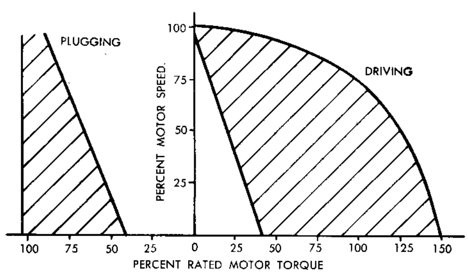


Fig. 103

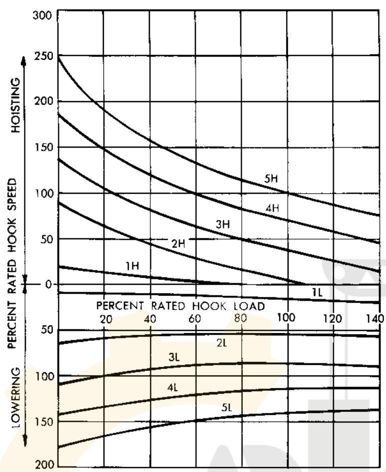


Fig. 104

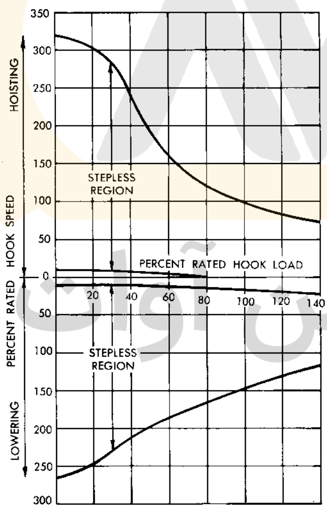


Fig. 105

performance. Acceleration and deceleration are smooth.

A complete unit usually consists of a D.C. hoist motor, shunt-wound electric holding brake, motor-generator set operating on A.C. power and supplying adjustable voltage D.C. power to the hoist motor, a push-button to start and stop the motor-generator, a master switch for controlling hoist and lower speeds, and an overhoist limit switch.

Reversing is accomplished by armature voltage polarity.

Speed control may be stepped or stepless and controlled by feedback so that control is from 0 to maximum.

Braking may be regenerative, dynamic or a combination of both.

The system is primarily the same for hoist, bridge, and trolley motions and the performance is shown in figure 104, stepped system and figure 105, stepless system.

Static and Adjustable Voltage systems are made by many manufacturers and realizing that the electrical control industry is progressing so rapidly, no specific references are made to manufacturer's names or trade names of their products. If further information is desired, contact the crane builder or the electrical manufacturer.

Table 24 — Comparison of AC Hoist Control Systems

Type of Control	Relative Cost	Safety	Hoisting	Lowering
Drum with automatic mechanical load brake.	A	Good	L.L. = Good R.L. = Good	Fair Good
Reversing magnetic with automatic mechanical load brake.	B	Excellent	L.L. = Good R.L. = Good	Fair Good
Reversing — counter-torque lowering.	B	Fair	L.L. = Fair R.L. = Fair	Poor Good
Reversing — DC dynamic lowering.	C	Fair	L.L. = Good R.L. = Good	Fair Good
Reversing — AC dynamic lowering.	C	Fair	L.L. = Good R.L. = Good	Fair Poor
Reversing — Single Phase Dynamic lowering.	B	Fair	L.L. = Good R.L. = Good	Poor Good
Reversing — Eddy Current load brake.	B	Good	L.L. = Good R.L. = Good	Excellent Excellent
Whiting Eddy Current with mech. load brake.	B	Excellent	L.L. = Good R.L. = Good	Excellent Excellent
Other trade-name controls. including static and adjustable voltage D.C.	D	Excellent	L.L. = Excellent R.L. = Excellent	Excellent Excellent

NOTES: Relative cost — A = lowest
L.L. = Light load
R.L. = Rated or near rated load

RESISTORS

All of the foregoing control, except that designated as "single speed control", or control for squirrel cage motors with two-speed windings, or static and adjustable voltage D.C., must have resistors which are rated according to the amount of time they can be in use and the approximate percent of full load current supplied to motor on first point of controller. Table 25, page 120, in line with NEMA standards, classifies resistors according to percent of full load current and torque on first point and duty cycle.

It is standard practice to furnish Class 152 resistors for cranes in intermittent service and Class 162 for cranes in heavy duty cycles. Class 154 resistors are recommended for 3-point hoist control. Other classes of resistors are furnished if more or less than 50% of full load current or torque must be supplied motor on first point or if duty cycle is more or less than indicated in table.

Table 25 — Resistor Classification

Approx. % Full Load Current on 1st Point	Starting Torque in % of Full Load Torque					Class No. According to Duty Cycle	
	DC MOTORS			AC MOTORS			
	Series	Compound	Shunt	1 Phase Starting	3 Phase Starting	15 Sec. Out of 60 Sec.	15 Sec. Out of 45 Sec.
25	8	12	25	15	25	151	161
50	30	40	50	30	50	152	162
70	50	60	70	40	70	153	163
100	100	100	100	55	100	154	164

Resistors are of the nonbreakable type, consisting of steel punched resistive units or edgewound alloy ribbon, and especially adapted to withstand severe vibration; due to the corrosion resistance of the resistive units, they are capable of withstanding exposure. Typical resistors used on cranes are shown in figures 106 and 107.

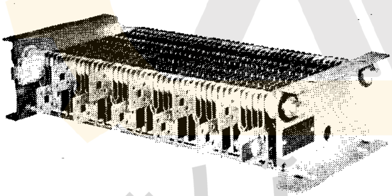


Fig. 106

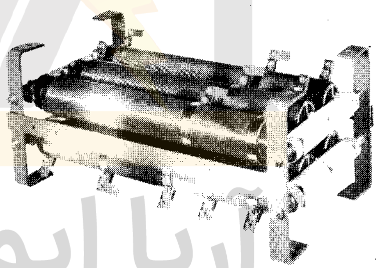


Fig. 107

Resistors for crane use are furnished with a permanent section of resistance to give better regulation during acceleration and to prevent the motor from stalling. This permanent section of resistance enables the motor to exert its maximum starting torque, regardless of how rapidly the operator throws the controller to full speed position.

To properly select resistors the motor horsepower, motor characteristics, and duty cycle of the crane should be known. With these factors, resistors of the proper size, NEMA class, and resistance value can be selected.

To obtain good service and long life from the resistors, it is important that good ventilation be provided in the immediate area. If enclosures are provided, they must be designed so that a natural flow of air will remove the heat from the resistors.

As most resistors are now mounted on the footwalk of the crane, personnel safety demands that a wire mesh or expanded metal guard be provided to prevent accidental contact with the resistors. Resistor units shall be supported so as to be as free as possible from vibration.

PROTECTIVE EQUIPMENT

As a safety requirement, all electrically powered cranes shall be provided with either a fused switchboard or a protective panel. The fused switchboard provides a main line disconnect switch and fuses for each motor circuit. These fuses are enclosed in a cabinet that cannot be opened when the main line switch is closed and the main line switch cannot be closed if the cabinet is open. Provision for locking the main line switch in the open position is included to prevent starting the crane while men are working on it.

To a large extent, the fused switchboard is superseded by the crane protective panel, that, in addition to a main line safety disconnect, provides overload relays and contactors giving overload and low-voltage protection for all motors on a crane. The initial cost of the protective panel is more than the fused switchboard although in service the protective panel would be less costly to maintain. There would be no fuse replacement costs with the protective panel. In cab-controlled cranes, the fused switchboard or protective panel would be mounted in the crane cab or within easy reach of the operator.

On floor-controlled cranes the disconnect means shall be mounted on the bridge or footwalk near the runway collectors and shall be one of the following types: (1) Non-conductive rope attached to the main disconnect switch handle; (2) An undervoltage trip for the main circuit breaker operated by an emergency stop button in the pendant push button station; (3) a main-line contactor operated by a switch or pushbutton in the pendant station.

Cranes equipped with magnetic control may have the protection for each motor incorporated on the control panel for that motor; a main-line safety disconnect switch should be mounted in the cab.

Cranes not equipped with spring-return controllers or momentary contact pushbuttons shall be provided with a device which will disconnect all motors from the line on failure of power and will not permit any motor to be restarted until all controller handles are brought to the "off" position, or a reset switch or button is operated.

For floor-operated cranes, the controllers, if rope operated, shall automatically return to the "off" position when released by the operator; pushbuttons in pendant stations shall return to the "off" position when pressure is released by the crane operator.

Automatic cranes shall be so designed that all motions shall fail safe, if any malfunction of operation occurs.

Remote operated cranes shall function so that if the control signal for any crane motion becomes ineffective that crane motion shall stop.

LIMIT SWITCHES

The hoisting motion of all electric travelling cranes shall be provided with an overtravel limit switch in the hoisting direction. Lower travel limit switches are recommended for all hoists where the hook enters pits or hatchways in the floor.

Limit switches have been described in this Section, Part B, pages 91 and 92.

WIRING

Cranes shall be wired in accordance with article 610 of the latest issue of the American Standard National Electrical Code. Applicable State Safety Code requirements must also be met. The usual practice is to completely wire the crane at the manufacturer's plant and only disassemble sufficiently for shipment.

The control circuit voltage shall not exceed 600 volts for A.C. or D.C. current. The voltage at pendant pushbuttons shall not exceed 150 volts for A.C. and 300 volts for D.C.

Where multiple conductor cable is used with a suspended push-button station, the station should be supported in some satisfactory manner that will protect the electrical conductors against strain.

It is recommended that cab lighting and convenience outlet be provided for the safety of the operator and convenience of maintenance personnel.

The exclusive use of stranded wire will prevent breakage in service due to vibration. This reduces maintenance and down-time of the crane. Except where heat makes necessary the use of asbestos covered wire, wire should be heat-resistant rubber- or thermoplastic-covered and run in conduit or steel raceways to protect it from deterioration and mechanical injury.

Heat shields should be provided under the control panels, wiring races and the crane cab floor when the crane is operated in areas of high ambient temperatures.

Reference to Table 16, pages 97, 98 and 99, will give the ampere rating of crane motors. From this rating and Table 26, page 123, the correct size of insulated wire for "short-time rating", 30° C. temperature rise after 30 minutes, can be determined. No wire smaller than No. 14 should be used.

Table 26 — Insulated-Wire rating in Amperes

Wire Gauge	Amperes	W.G.	Amperes	W.G.	Amperes
14	26	4	117	000	341
12	33	3	141	0000	369
10	43	2	160	250,000 CM	420
8	60	1	175	300,000 CM	582
6	86	0	233	350,000 CM	646
5	95	00	267	400,000 CM	688
				500,000 CM	847

Bridge conductors and collectors have been described in Part A, pages 73, 74 and 75, and trolley collectors in Part B, page 94. See Section XIV for runway conductors.

CONTROL ARRANGEMENTS

Figure 108 shows the arrangement of controllers or master switches in the cabs of three-motor cranes and Figure 109 gives the layouts for four-motor cranes.

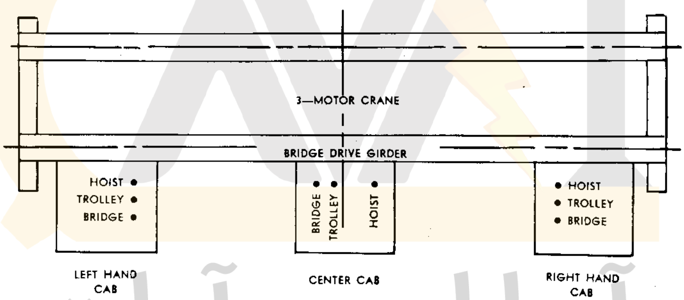


Fig. 108

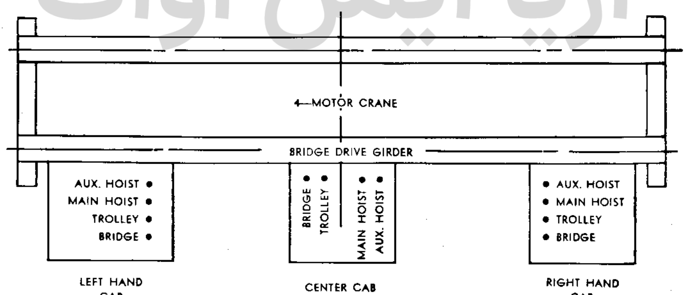


Fig. 109

The crane user may have an individual arrangement for his peculiar operation which will be preferred over those shown here. Special attention must be given these layouts if more than one crane operates on a runway so that the operators can prevent collisions.

With magnetic controls, more comfort and convenience can be offered the crane operator. Better visibility, sit-down operation, less fatigue, and therefore greater safety are all benefits from the initial installation of this type of control.

Lever operated controllers shall be provided with a notch or latch which in the "off" position prevents the handle from being inadvertently moved to the "on" position. An "off" detent or spring return arrangement is acceptable. The operating handles shall be located within convenient reach of the operator and if practicable, the movement of each handle should be in the same general directions as the resultant movements of the crane load. The control for bridge and trolley travel shall be so located that the operator can readily face the direction of travel.

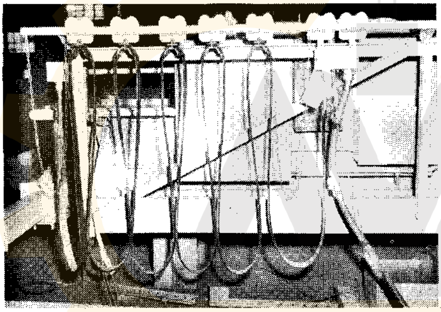


Fig. 110

Control arrangements for floor-controlled cranes are influenced by the aisles, balconies, pits, and machine or storage layout in the area to be served by the crane. In any arrangement the pendant ropes or push-button usually extend to within 4'-0" above the operating floor. Multilevel operation for push-button control may be effected by raising or lowering the push-button station on a take-up reel. The station may also be suspended from a trolley system mounted on the crane hand-rail and thereby cover the entire operating area independent of the hook position. This trolley system may utilize I-beam, pipe, or commercial track and suitable trolleys for the suspension of the multi-conductor cables as shown in figure 110.

For special installations, an operating pulpit or station may be located at one spot in the service area, or remotely located for controlling all the motions of the crane. This arrangement requires many conductors on the crane runway or overhead on the roof trusses or ceiling.

Radio remote crane control has gained wide acceptance in the last few years. Many manufacturers have entered the field and use various circuits to accomplish the desired operation. All basic units are similar in outward appearance and consist of the following units: A portable transmitter worn by the operator; an antenna and receiver on the bridge; an intermediate relay panel on the bridge to amplify the signals for the crane contactors; and possibly a rotary converter or solid state inverter to change D.C. to A.C. on D.C. operated cranes.

Advantages for this control system include: elimination of the crane cab and the operator in that cab; eliminates missed or misinterpreted signals between crane operator and floor men which may result in accident or damage; productivity increases when the hooker is also the dispatcher of the crane, no idle operator in the cab; the operator is in a position to direct precision spotting of the load because he is standing near the load with his control; added safety with operator on floor in full view of the load and surrounding area and not dependent upon position of control station in relation to load as would be the case in a floor-controlled crane.

The working range of radio control is usually within the 200 to 300 foot range so that the operator remains near the crane and load. This creates the problem of limiting the range of signals while retaining sufficient power to work the circuits and override interference. The system must be reliable and fail-safe. The crane should not take off on its own, respond to or generate false commands, and in case electronic failure occurs, the crane must stop. Technical assistance by the manufacturer should be a requirement at installation and initial operation.

Automatic operation of cranes in cycle operations for material handling in the fields of metal melting, steel warehousing and package storage is gaining wide acceptance. This system is based on a punched card and control components that send the crane to the selected area, pick up the load and return it to the point of origin without further direction from the floor-man. Speed of handling, elimination of crane operators, either cab or floor, and better utility of storage areas are some of the advantages of this system.

The crane builder is prepared to solve control problems and make recommendations based on available control systems that have been approved through years of development, experience, and proven use.

SECTION X — CRANE COMPARISON DATA

Section VII outlines a crane inquiry and Section VIII gives general specifications. Section IX is devoted to crane design details that should be incorporated in a quality crane. The next step is the actual purchase and installation of the crane. Some purchasers have sufficient confidence in a certain crane builder to purchase without competition; others call for bids and then follow their best judgment as to which offering is the most attractive; while some purchase purely on a price basis. Frequently this latter class receives the least for its money.

After the capacity, speeds, service, electrical current, external dimensions, lift and hook approaches have been checked, it is equally important that efficiency of all drives, design of components, materials used, oil-tightness, safety features, life expectancy of wearing parts, ease of inspection, and accessibility of parts for maintenance be given special attention. These all provide "owner benefits" and should be carefully considered in comparing prices of cranes.

Besides the "owner benefits" there are other intangibles such as: ownership and operation of an up-to-date piece of machinery; pride of workmen and operators to keep good equipment in first-class shape; less personal fatigue by elimination of noisy cranes; and the high speeds and fast acceleration which can speed up production.

Where competitive bids are secured, the wise purchaser will carefully analyze and compare the specifications to select a crane having the greatest value, and one that will give the best service in his particular plant with the minimum of operating and maintenance expense.

For your guidance in making an analysis as described, a list of points to be checked and how to fill in the items for comparison purposes follows, covering a Class C, 25 ton, 4-motor, 80'0" span crane for indoor operation.

All the information requested should be shown in the crane builder's proposal specifications and made a part of his quotation.

Fig. 111 shows an assembled crane with machinery cutaways that should aid in identifying units found in the following comparison sheets.

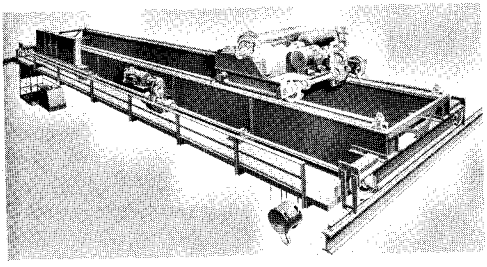


Fig. 111

CRANE PURCHASE COMPARISON AND DATA FORM

GENERAL DESCRIPTION

Capacity: Main Hoist *25* tons; Auxiliary Hoist *5* tons
Span: *80* ft. *0* in.; Lift: *25* ft. *0* in.
Current: *3* phase, *60* cycles, *440* volts
Service: Class *C, Assembly* Indoor or Outdoor: *Indoor*

Manufacturer	1. *Whiting*	2.	3.
1. BRIDGE GIRDER: Type	*Welded Box*		
A. Section	—		
B. Bridge rail	*80#*		
2. BRIDGE TRUCKS: Type	*Structural Steel*		
A. Axle	*Rotating - Alloy*		
B. Bearing	*Timken*		
C. Wheel dia. - mat'l.	*21" Rolled Steel*		
D. Maximum wheel load	*57,400#*		
E. Wheel base	*12'-6"*		
F. Bearing Life (B-10)	*14000 Hours*		
G. Gear Reduction at wheels	*None*		
3. BRIDGE BUMPERS: Type	*Wood*		
A. Quantity	*4*		
4. BRIDGE DRIVE: Type	*Single at CL Span*		
A. Type of Gearing	*Herringbone & Spur*		
B. Enclosure	*Oil-Tight*		
C. Lubrication	*Splash Lubrication*		
D. Bearings	*Ball and Roller*		
E. Overhung gears or pinions	*None*		
5. CROSS SHAFT BEARINGS: Type	*S-A. Pillow Block*		
6. CROSS SHAFT COUPLINGS:			
A. Type & material	*Flanged Steel*		
B. Guards	*Yes*		
7. MOTOR COUPLINGS:			
A. Type & material	*Flexible C.I.*		
8. BRIDGE BRAKE: Type	*Hydraulic*		
A. Size	*10"*		
9. BRIDGE FOOTWALK: Type	*Floor Plate*		
A. Drive side	*Full Length*		
B. Idler side	*None*		

Manufacturer	*1. Whiting*	2.	3. ....
10. BRIDGE CONDUCTORS:		....	....
Type	*H.D. Copper Wires*	....	....
A. Open Encl. Guarded	*Open*	....	....
11. BRIDGE COLLECTORS:			
Type	*Double Wheel*	....	....
12. OPERATOR'S CAB: Type	*Open*	....	....
A. Location	*R.H. End*	....	....
B. Visibility	*Excellent*	....	....
13. MISCELLANEOUS	*Controls on Walk* *Master Switches in Cab*	....	....
14. MAIN HOIST:			
A. Block Construction	*Short Type - Enclosed*	....	....
B. Hook type & mat'l.	*Plain - Forging*	....	....
C. Sheave dia. & mat'l.	*15" - 16½" Steel*	....	....
D. Sheave bearings-type	*Ball or Roller*	....	....
E. Rope size & type	*⅝" 6 x 37 IPS.*	....	....
F. Rope - no. of parts	*12*	....	....
G. Drum dia. & mat'l.	*15" Steel*	....	....
H. Hoist unit - no. of reductions	*Two*	....	....
J. Type of gearing	*Herringbone*	....	....
K. Bearings: type	*Ball or Roller*	....	....
L. Lubrication	*Oil Splash*	....	....
M. Enclosure	*Steel - Oil-Tight*	....	....
N. Overhung gears or pinions	*None*	....	....
O. Mechanical load brake	*Yes*	....	....
P. Electrical braking type	—	....	....
Q. Electric holding brake-type	*Solenoid*	....	....
1. brake rating	*140 lb.-ft.*	....	....
R. Motor Coupling	*Flexible C.I.*	....	....
S. Limit Switch - type	*Direct-Acting Paddle*	....	....
T. Miscellaneous			
1. Hook lock	*No*	....	....
2. Hook safety latch	*No*	....	....
15. TROLLEY DRIVE:	*Single at CL Gauge*	....	....
A. Type of gearing	*Herringbone & Spur*	....	....
B. Enclosure	*Oil-Tight*	....	....
C. Lubrication	*Splash*	....	....
D. Bearings	*Ball & Roller*	....	....
E. Overhung gears or pinions	*None*	....	....
F. Shaft couplings	*Flanged Steel*	....	....
16. TROLLEY TRAVEL BRAKE: Type	*None*	....	....
A. Size	—	....	....

Manufacturer	1. *Whiting*	2..............	3..............
17. TROLLEY TRUCK: Type	*Steel Box*	....	....
A. Axle type	*Rotating*	....	....
B. Wheel dia. & mat'l.	*10" Forged Steel*	....	....
C. Bearings	*Roller*	....	....
D. Gear reduction @ wheels	*None*	....	....
18. TROLLEY FRAME: Construction	*Welded Steel*	....	....
19. TROLLEY COLLECTORS: Type	*Carbon Insert Shoes*	....	....
20. TROLLEY BUMPERS: Type	*None*	....	....
A. Quantity	—	....	....
21. AUXILIARY HOIST:			
A. Block Construction	*Short Type - Enclosed*	....	....
B. Hook type & mat'l.	*Plain-Forging*	....	....
C. Sheave dia. - mat'l.	*12" Steel*	....	....
D. Sheave bearings - type	*Ball*	....	....
E. Rope size & type	*½ 6 x 37 IPS*	....	....
F. Rope - no. of parts	*4*	....	....
G. Drum dia. & mat'l.	*12" C.I.*	....	....
H. Hoist unit - no. of reductions	*2*	....	....
J. Type of gearing	*Herringbone & Spur*	....	....
K. Bearing - type	*Ball & Roller*	....	....
L. Lubrication	*Oil Splash*	....	....
M. Enclosure	*Steel - Oil-Tight*	....	....
N. Overhung gears or pinions	*None*	....	....
O. Mechanical load brake	*Yes*	....	....
P. Electrical braking type	—	....	....
Q. Electric holding brake - type	*Solenoid*	....	....
1. brake - rating	*140 lb.-ft.*	....	....
R. Motor Coupling	*Flexible - C.I.*	....	....
S. Limit switch - type	*Direct-Acting Paddle*	....	....
T. Miscellaneous			
1. Hook lock	*No*	....	....
2. Hook safety latch	*No*	....	....
22. MOTORS: Type	*Wound Rotor - Crane Type*	....	....
A. Open	*Yes*	....	....
B. Enclosed	—	....	....
C. Bearings	*Ball*	....	....
23. SPEEDS & MOTOR SIZES			
A. Main hoist - FPM	*14*	....	....
B. HP & RPM	*25 @ 1200*	....	....
C. Rating	*30' 70°*	....	....

Manufacturer	1. *Whiting*	2..............	3..............
23. Cont'd.			
D. Aux. hoist - FPM	*35*	....	....
E. HP & RPM	*15 @ 1200*	....	....
F. Rating	*30' 70°*	....	....
G. Trolley travel - FPM	*150*	....	....
H. HP & RPM	*5 @ 1200*	....	....
J. Rating	*30' 70°*	....	....
K. Bridge Travel - FPM	*300*	....	....
L. HP & RPM	*25 @ 1200*	....	....
M. Rating	*30' 70°*	....	....
24. CONTROL: Type	*Magnetic-Reversing*	....	....
A. Enclosure	*Gasketed*	....	....
B. Speed points:			
Main hoist	*5*	....	....
Aux. Hoist	*5*	....	....
Trolley Travel	*5*	....	....
Bridge Travel	*5*	....	....
C. Resistor: Type	*Non-Breakable*	....	....
Resistor: Class	*152*	....	....
D. Special features:	*Overload Protection for Each Motor*	....	....
25. MAIN LINE SWITCH: Type	*Manual Knife Switch*	....	....
26. ACCESSORIES			
A. Magnet & Controller	*None*	....	....
B. Cable Reel	*None*	....	....
C. Motor Generator Set	*None*	....	....
D. Bucket	*None*	....	....
E. Grapple	*None*	....	....
F. Runway conductors	*None*	....	....
G. Runway rail	*None*	....	....
H. Others	—	....	....
27. Components accessible for inspection & maintenance	*Yes*	....	....
28. LUBRICATION:	*Oil Bath & Grease Fittings*	....	....
29. PRICE			
30. WEIGHT:	*77,300#*	....	....
31. FOB POINT:	*Harvey, Ill.*		
32. FREEFREIGHT:	—		
33. DELIVERY:	________ *Weeks*		

All differences in specifications should be checked and evaluated according to the information given in Section IX, Parts A, B, and C on Crane Design.

SECTION XI – SPECIAL PURPOSE CRANES

In many industries, a specific material must be handled continuously by an overhead crane. A special means of conveying the material, other than by the attachment to a crane hook or sling, must be utilized. Cranes designed for handling a certain material fall into the classification of Special Purpose Cranes. These cranes are designed by using standard components in an arrangement as required to perform the given operation.

Cranes used in conjunction with a clam-shell bucket to handle such materials as coal, ashes, limestone, coke, sand, cement, clinkers, and fertilizers fall in the Class E Service range and are made rugged for severe and continuous service.

A magnet attached to the hook of a Class E crane enables it to easily handle slabs, pig iron, scrap, borings and trimmings without the help of a hook-on man. Much material can be handled in a short time. This crane also requires rugged construction and additional clearances to provide for the safe use of a large magnet.

Lumber handling, locomotive handling, paper and wire reel handling, brick and plate glass handling as well as cupola-charging cranes are further examples of special purpose cranes.

The basic designs of components as detailed in Section IX also apply to these cranes. Variations and special arrangement of these components will be described in this section under each type.

BUCKET-HANDLING CRANES

A bucket handling crane provides a means of handling bulk material on a one-man basis. The crane operator, by means of a clam-shell type bucket, is the only man required in the handling of bulk materials from cars to storage piles and from storage piles or cars to the production area for further processing and then shipping.

The bridge of a bucket crane follows the design of a standard bridge except that a larger bridge motor may be required to take care of the heating of the motor due to the continuous operating cycle. If no fast cycle is involved the only change would be the enlarged gauge and the provision for additional clearance between the bucket and the operator's cab. If the bucket opens with the cutting edges parallel with the bridge girders, the bucket is said to open at right angles to the bridge girders and if the cutting edge is at right angles to the girders, the bucket opens parallel with the girders. At least 18 inches clearance should be provided between the face of the cab and the edge of the bucket in its open position. The live load will include the weight of the bucket, Table 29, the material to its heaped capacity, Table 32, and the much heavier trolley due to the double-hoist design, Table 27.

Table 27 gives the capacity, dimensions and weights of bucket trolleys. By modifying the clearances and weights shown in Section

VI, an approximate clearance diagram for a bucket crane can be made. Table 28 shows the range of capacity and recommended speeds for bucket cranes.

Table 27 — Bucket Trolleys

Cap'y. in Cu. Yds.	Wheel Base	Standard Gauge (K)	Max. Lift (L)	Height of Trolley	Drum Dia.	Max. Load on Drums	Top of Bucket to Top of Trolley	Weight of Trolley
¾	7′9″	8′0″	50′0″	2′9″	15″	5000	4′3″	13,000
1	7′9″	8′0″	50′0″	2′9″	15″	5000	4′3″	15,000
1½	8′6″	9′0″	50′0″	3′1″	15″	10000	4′7″	18,000
2	8′6″	9′0″	50′0″	3′1″	15″	10000	4′7″	20,000
3	9′6″	9′6″	50′0″	4′0″	18″	18000	5′6″	25,000
4	11′8″	9′6″	75′0″	4′8″	24″	22000	6′2″	45,000
5	12′0″	10′6″	75′0″	5′0″	27″	30000	7′8″	56,000
6	12′6″	11′0″	75′0″	5′8″	27″	34000	8′6″	64,000

Table 28 — Bucket Crane Speeds

Capy.	Hoist	Trolley	Bridge
¾	60-140	150	400
1	75-120	150	400
1½	75-250	200	400
2	75-200	200	400
3	60-200	200	400
4	100-200	200	400
5	100-160	200	400
6	80-160	200	400

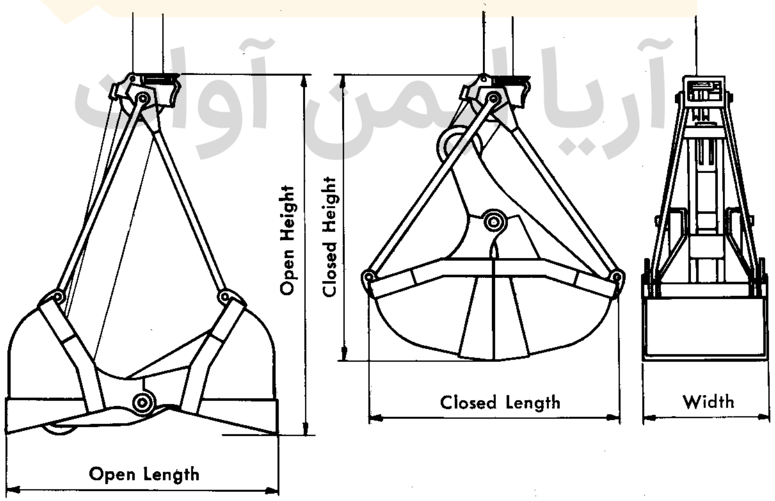


Fig. 112

Table 29 — Capacities, Weights, and Sizes of Standard Buckets (Fig. 112)
BLAW-KNOX DIVISION

Bucket No.	Capacity		Height		Length		Width	Sheave Diameter	Rope Diameter	Rope Length to Reeve Bckt.	Line Pulled in closing	Weight
	Cubic Yards	Heaped Cu. Ft.	Closed	Open	Closed	Open						
666	½	18	6′4″	7′10″	5′3″	6′0″	2′7″	11⅜″	⅝″	39′8″	26′2″	2520
672	¾	27	7′1″	8′9″	5′11″	6′6″	3′2″	13″	¾″	44′5″	29′2″	3240
680	1	36	7′9″	9′10″	6′9″	7′3″	3′2″	14½″	¾″	49′9″	33′0″	4050
684	1¼	45	8′0″	10′2″	7′2″	7′8″	3′5″	14½″	¾″	51′3″	34′7″	4325
716H	1½	54	8′8″	10′11″	7′5″	8′1″	3′8″	16″	¾″	55′3″	36′7″	5060
720S	1¾	63	9′1″	11′5″	7′11″	8′7″	3′10″	16″	¾″	57′4″	38′8″	5760
724H	2	72	9′7″	12′1″	8′4″	8′11″	4′0″	18″	⅞″	60′11″	40′7″	6900
730S	2½	90	10′5″	13′1″	9′0″	9′11″	4′4″	19½″	1″	66′2″	43′5″	8540

Remarks: General purpose bucket — Two-line lever arm type

612	1	35	7′8″	8′10″	5′7″	7′1″	3′3″	14½″	¾″	36′11″	23′7″	3330
616	1¼	42	7′11″	9′2″	5′11″	7′6″	3′5″	14½″	¾″	36′7″	24′11″	3740
716	1½	50	7′11″	9′4″	6′2″	7′11″	3′10″	16″	¾″	38′11″	24′1″	4460
722	1¾	57	8′5″	9′5″	6′1″	8′10″	4′4″	16″	¾″	39′3″	24′4″	4975
724	2	64	9′0″	10′0″	6′4″	9′2″	4′6″	18″	⅞″	41′11″	25′5″	5700
726	2¼	75	9′3″	10′3″	6′7″	9′7″	4′8″	18″	⅞″	43′0″	26′5″	6170
730	2½	85	9′6″	10′7″	6′9″	9′11″	4′10″	18″	⅞″	43′10″	27′5″	6510
734	3	97	10′2″	11′4″	7′3″	10′6″	5′2″	19½″	1″	46′11″	29′0″	8010
7403	4	120	9′10″	11′4″	7′7″	9′11″	5′11″	19½″	1″	57′0″	34′7″	9875

Remarks: Rehandling bucket, normal proportions, two-line lever arm type

612	1	35	7′8″	8′10″	5′7″	7′1″	3′3″	14½″	¾″	36′11″	23′7″	3310
716	1½	50	7′11″	9′4″	6′2″	7′11″	3′10″	16″	¾″	38′11″	24′1″	4460
724	2	64	9′0″	10′0″	6′4″	9′2″	4′6″	18″	⅞″	41′11″	25′5″	5700
730	2½	85	9′6″	10′7″	6′9″	9′11″	4′10″	18″	⅞″	43′10″	27′5″	6510
734C	3	97	10′2″	11′4″	7′3″	10′6″	5′2″	19½″	1″	46′11″	29′0″	7900
734SI	3	93	9′8″	10′9″	6′9″	9′9″	5′10″	19½″	1″	54′7″	32′4″	7960
734S	3	93	9′8″	10′9″	6′9″	9′9″	5′10″	19½″	1″	54′7″	32′4″	8750
736	3½	108	9′10″	11′4″	7′3″	9′4″	5′10″	21″	1″	56′8″	33′0″	9400
7402	4	120	9′10″	12′2″	8′8″	9′11″	5′11″	19½″	1⅛″	60′8″	38′7″	9920
7500	5	187	11′3″	13′4″	9′1″	11′8″	7′5″	22½″	1⅛″	54′11″	34′6″	12120
7600	6	225	12′2″	14′3″	9′8″	12′7″	7′9″	24″	1¼″	58′10″	37′4″	15000

Remarks: Industrial application buckets. Two-line and three-line lever arm type

Table 29 (cont'd) Capacities, Weights, and Sizes of Standard Buckets

WILLIAMS BUCKET DIVISION McDOWELL-WELLMAN ENGINEERING COMPANY

Bucket No.	Capacity Cubic Yards	Capacity Heaped Cu. Ft.	Height Closed	Height Open	Length Closed	Length Open	Width	Sheave Diameter	Rope Diameter	Rope Length to Reeve Bckt.	Line Pulled in closing	Weight
14F	½	—	6′9″	7′10″	5′4″	6′6″	2′6″	—	⅝″	30′1″	19′7″	2600
20F	¾	—	7′3″	8′10″	5′11″	6′11″	3′1″	—	¾″	34′2″	22′6″	3300
27F	1	—	8′0″	9′8″	6′4″	7′6″	3′5″	—	¾″	37′5″	24′6″	3700
34F	1¼	—	8′2″	10′0″	6′8″	7′10″	3′8″	—	¾″	38′3″	25′4″	4100
40F	1½	—	9′3″	11′3″	7′3″	8′6″	3′10″	—	⅞″	44′0″	28′4″	5350
47F	1¾	—	9′6″	11′8″	7′8″	9′0″	3′10″	—	⅞″	45′3″	29′4″	5700
54F	2	—	9′7″	11′7″	7′7″	9′0″	4′4″	—	⅞″	45′3″	29′3″	6200
68F	2½	—	9′10″	11′9″	7′9″	9′5″	4′10″	—	1″	45′7″	30′0″	7500
81F	3	—	10′8″	12′10″	8′1″	9′4″	5′4″	—	1″	49′10″	31′5″	9500

Remarks: General purpose bucket "Favorite"

THE HAYWARD COMPANY

	½	17	5′3″	5′9″	4′1″	5′11″	3′0″	—	½″	15′0″	11′3″	1950
	¾	24	6′1″	7′0″	5′1″	6′11″	3′4″	—	9/16″	19′3″	15′0″	2800
	1	34	6′11″	7′10″	5′8″	8′1″	3′4″	—	⅝″	20′0″	16′0″	3400
	1¼	41	6′11″	7′10″	5′8″	8′1″	3′11″	—	⅝″	20′0″	16′0″	3600
	1½	51	7′7″	8′8″	6′2″	8′10″	4′2″	—	¾″	22′0″	18′0″	4800
	2	68	7′10″	8′11″	6′4″	8′10″	5′2″	—	⅞″	24′0″	20′0″	5950
	2½	85	8′9″	10′0″	7′0″	9′9″	5′3″	—	⅞″	27′0″	21′0″	7700
	3	100	8′10″	10′0″	7′0″	9′10″	6′2″	—	1″	27′0″	21′0″	8200
	4	135	9′11″	11′8″	8′7″	11′4″	6′3″	—	1″	32′0″	23′6″	13700

Remarks: Rehandling Bucket E-16

ELECTRIC MOTOR BUCKET — HOOK-ON TYPE (No Equalizer Required)

	¾	—	5′9″	6′5″	4′1″	5′5″	3′10″	—	—	—	—	3200
	1	—	6′7″	7′4″	4′8″	6′4″	4′0″	—	—	—	—	5200
	1¼	—	7′5″	8′1″	5′1″	7′4″	4′3″	—	—	—	—	5600
	1½	—	7′5″	8′1″	5′1″	7′4″	4′11″	—	—	—	—	5900
	2	—	9′0″	10′0″	6′1″	8′9″	5′7″	—	—	—	—	9000
	2½	—	9′4″	10′5″	7′0″	9′9″	5′0″	—	—	—	—	10000
	3	—	9′4″	10′5″	7′0″	9′9″	5′10″	—	—	—	—	10500

Table 29 (cont'd) Single Line Hook-On Buckets. Normal Weight — Open Head
BLAW-KNOX DIVISION

Bucket No.	Capacity		Height		Length		Width	Sheave Diameter	Rope Diameter	Rope Length to Reeve Bckt.	Line Pulled in closing	Weight
	Cubic Yards	Heaped Cu. Ft.	Closed	Open	Closed	Open						
306	½	20	—	5′10″	4′5″	5′1″	3′0″	8½″	½″	7′3″*	5′10″**	2200
311	¾	27	—	6′11″	4′8″	6′7″	3′0″	10″	½″	8′9″*	6′6″**	2900
311W	1	36	—	6′11″	4′8″	6′7″	4′3″	10″	½″	8′9″*	6′6″**	3400
0-3100	1¼	36	—	8′0″	5′10″	7′1″	3′6″	12″	⅝″	9′7″*	7′9″**	4100
0-3125	1½	45	—	8′0″	5′10″	7′1″	4′4″	12″	⅝″	9′7″*	7′9″**	4650
0-3175	2	63	—	9′2″	6′8″	8′2″	4′8″	14″	¾″	11′3″*	9′2″**	6600
0-334	2¼	72	—	9′2″	7′2″	8′1″	4′9″	15″	¾″	12′2″*	9′6″**	7200
0-3175-2	3	86	—	9′3″	7′0″	8′7″	5′8″	14″	¾″	11′4″*	9′2″**	7350

*—Operating headroom — distance from palm of hook to bottom of bucket (tripped open).
**—Necessary hook travel to close bucket

Table 30 — Dumping Angles
(Angles at which different materials will slide out of a tipped body.)

Material	Angle	Material	Angle	Material	Angle
Ashes, dry	33°	Clay	45°	Ore, dry	30°
Ashes, moist	36°	Coal, hard	24°	Ore, fresh mined	37°
Ashes, wet	30°	Coal, soft	30°	Rubble	45°
Asphalt	45°	Coke	23°		
		Concrete, soft	30°		
Brick	33°			Sand, dry	35°
				Sand, moist	40°
Cinders, dry	33°	Earth, loose	28°	Sand, and crushed stone	27°
Cinders, moist	34°	Earth, compact	50°	Stone	30°
Cinders, wet	31°			Stone, broken	27°
Cinders, and clay	30°	Garbage	30°	Stone, crushed	30°
		Gravel	40°		

Table 31 — Measure Equivalents

1728 cu. in. = 1 cu. ft.	128.00 cu. ft. = 1 cord
2150 cu. in. = 1 bushel	1.24 cu. ft. = 1 bushel
7056 cu. in. = 1 barrel	4.08 cu. ft. = 1 barrel
231 cu. in. = 1 gallon	10.75 cu. ft. = 1 small bale
144 cu. in. = 1 board foot	20-23 cu. ft. = 1 cotton bale
27 cu. ft. = 1 cubic yard	

Table 32 — Weights of Various Materials Handled by Bucket Cranes

Material	Lbs. Per Cu. Yd.	Tons Per Cu. Yd.	Material	Lbs. Per Cu. Yd.	Tons Per Cu. Yd.
Ashes	1080	.54	Earth, moist, packed	2592	1.29
Asphalt	2360	1.18	Earth, mud, flowing	2916	1.46
			Earth, mud, packed	3105	1.55
Basalt rock, piled	2600	1.30			
Bauxite	2160	1.00	Garbage	800	.40
Bluestone	2970	1.48	Gravel, dry	2970	1.48
Brick, common	3240	1.62	Gravel, wet	3400	1.70
Brick, pressed	3780	1.87			
Brick, soft	2700	1.35	Hornblende	2900	1.45
Cement			Iron borings	1200	.60
Portland, Loose	2430	1.21	Iron ore	4350	2.17
Cement, Portland, Set	4941	2.47			
Cement, stone, sand	3888	1.94	Limestone, Loose	2592	1.29
Cement, slag, etc.	3510	1.75	Marble, loose	2592	1.29
Cement, cinder, etc.	2700	1.35			
Cinders	1080	.54	Riprap, limestone	2250	1.11
Clay, dry	1701	.85	Riprap, sandstone	2430	1.21
Clay, damp, plastic	2970	1.48	Riprap, shale	2835	1.42
Clay and gravel, dry	2700	1.35	Rubbish	270	.13
Clay, Marl	3699	1.85			
Coal, Anthracite	1450	.73	Sand, gravel		
Coal, Bituminous			dry, loose	2620	1.31
Lignite	1300	.65	Sand, gravel		
Coal, peat, turf	630	.31	dry, packed	2970	1.48
Coal, charcoal	325	.16	Shale,		
Coal, coke	760	.38	quarried & piled	2480	1.24
Crushed stone	2700	1.35	Slag, bank	1890	.94
			Slag, granulated	1400	.70
Dolomite	2430	1.21	Slate	2480	1.34
			Sulphur	3375	1.68
Earth, dry, loose	2052	1.02	Steel, punchings	7300	3.65
Earth, dry, packed	2565	1.28	Steel, turnings	1300-	
Earth, moist, loose	2106	1.05		2700	

The machinery parts of the bridge are chosen to produce longer gearing and bearing life based on the larger bridge motor made necessary by the heavier bridge, trolley and allowance for impact in the girder design. Usually it is a production crane with a fast cycle that requires higher than normal speeds, which again adds to the dead weight. It is of extreme importance that special attention be given the crane design as it affects the lubrication and dust-proofing of all wearing parts.

Figure 113 shows a typical bucket trolley with its two-drum construction. These drums are usually mounted parallel with the bridge girders to keep the ropes as far away from the girders as possible in all positions of the bucket. The drums are of the same diameter and driven by independently controlled motors through separate gear cases.

One drum is direct reeved to the closing line of the bucket, while the other is reeved for two parts direct to the holding lines which are attached to the bucket by means of an equalizing bar.

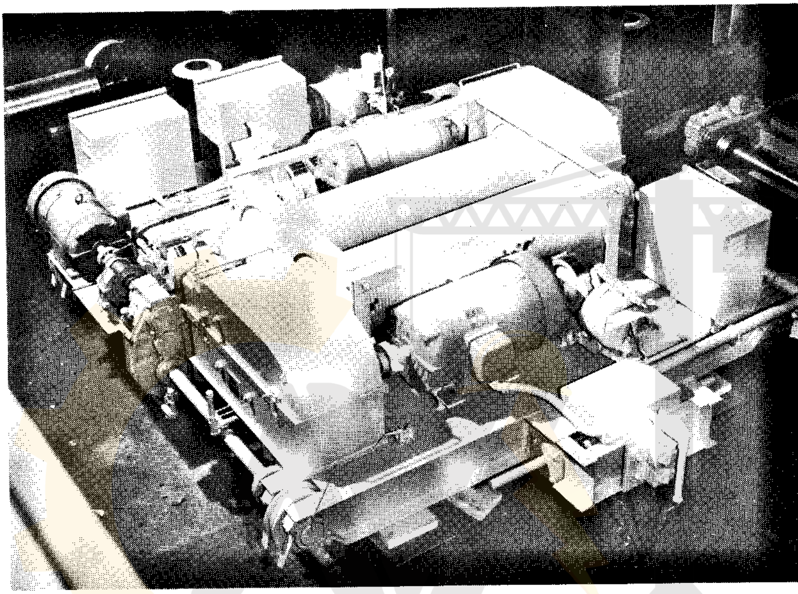


Fig. 113

The horsepower of the hoist motor is calculated by the hoist motor formula, page 86, with the addition of a .7 multiplier for each motor. Each hoist motor, therefore, is rated at seven-tenths of the full load requirement. In operation, the crane operator becomes skilled in the manipulation of control levers and is able to distribute the load on both drums after the bucket-closing operation has been completed. Each motor is equipped with an electric holding brake rated in excess of the motor torque. No automatic mechanical load brake is used in the hoist gear drive.

Special provision must be made for the protection of parts adjacent to the hoisting ropes. Guards must be provided at the ends of the drums to prevent the ropes from interfering with other trolley parts due to the rope action. After the bucket strikes the material pile and the operator fails to quickly stop the lowering movement, the ropes will continue to unwrap resulting in a condition of the ropes being out of their grooves and in extreme cases, to be entirely free from the drum. Guards must prevent the rope from looping over the ends of the drums or gear case. Special provision must also be made to prevent the ropes from chafing against the edge of trolley deck or bridge girders.

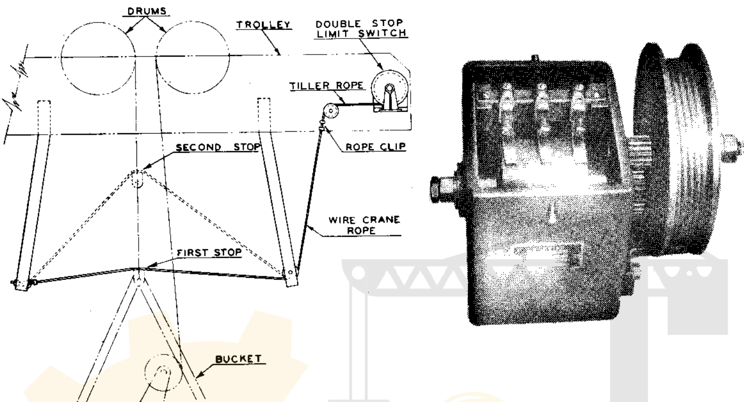


Fig. 114

It is recommended that a double-stop limit switch be furnished to provide a safe stop at all times. Figure 114 shows the mounting and operation of such a switch. The first limit is set low enough so that when the bucket is run into the limit switch cable, the bucket will not drift into the trolley load-girt. The second limit is set so that the bucket safely clears the load girt. When the bucket opens the first limit, and further lift is needed, additional height may be reached by push-button release of the first limit. After reaching the second limit, it is impossible to hoist further, but the bucket may be lowered to any position by reversing the controller.

The trolley drive design is similar to a standard trolley except for the provision of larger motor and added life.

A bucket crane installation is shown in Figure 115.

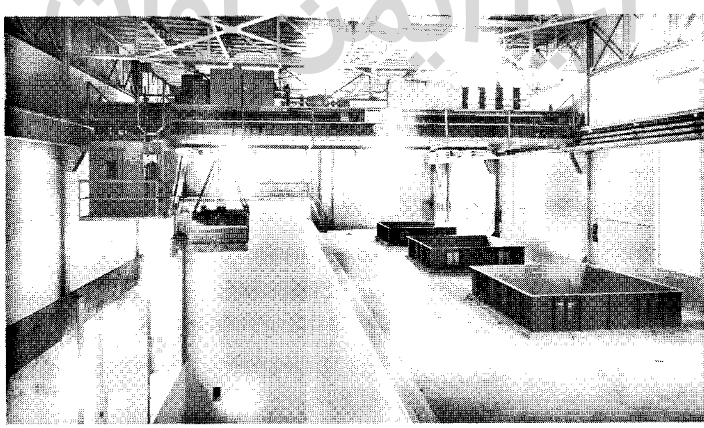


Fig. 115

In many plants the work for a bucket crane may be intermittent and not enough to warrant the installation of a special purpose crane. This condition may be met by a special type bucket, single line, Table 29, Figure 116, or motor-operated, Table 29, Figure 117, which can be readily attached to a standard crane hook. This allows one crane to serve both for standard hook lifts and as a bucket crane. The motor-operated bucket requires less headroom than the single line but is more expensive, requiring cable-reels, cable, extra conductors, and control on the crane. Hooks of these cranes shall be provided with hook latches to prevent the bucket from leaving the hook; and with hook locks to prevent rotation of the bucket.

Fig. 116

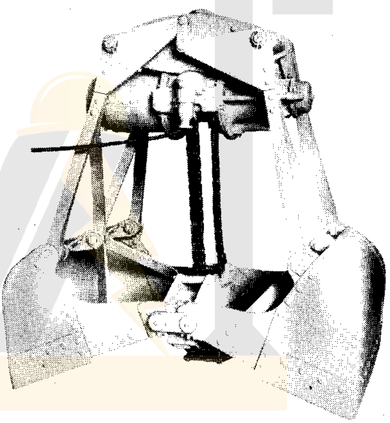


Fig. 117

The single-line bucket automatically digs and then closes when the crane hook is raised and is tripped to the open position by pulling a cord or having the bucket lever strike a fixture on the trolley when the bucket is in its high position. Although less in cost than the motor-operated bucket, it is not as popular due to the larger physical dimensions, more headroom required for equivalent lifts, and its heavier weight for equal capacities.

Measure equivalents used in determining the amount of material to be handled is given in Table 31, Page 135, and the weight of common materials in pounds and tons per cubic yard is found in Table 32, Page 136. For general information in handling certain materials, the dumping angle is shown in Table 30, Page 135.

Steel scrap may also be handled by a bucket crane equipped with a special two line bucket.

A bucket handling crane is so important in its application that a thorough study of its intended operation is required before a quotation is made. The duty cycle, following the example in Section V, Page 24, Ex. 2, should be determined by actual layout of all bridge and trolley travels so that speeds selected will be adequate. Giving the crane builder full information, will assure the purchaser of an adequate crane that will give uninterrupted service over a long period of operation, thus saving down-time and lost production.

MAGNET HANDLING CRANES

A magnet attached to the hook of a standard or special trolley provides one-man operation in the handling of ferrous materials in foundry charge make-up, scrap, and steel storage yards. If the crane is used occasionally to load or unload scrap, transfer scrap about the yard, or make up charges for cupola melting, it may be a standard crane with fast speeds and its clearances would be similar to those shown in Section VI except that dimension B shall be increased by the amount shown as "headroom required", Table 33, Page 142, to arrive at the overall height of the building or yard runway.

If the crane must meet a severe duty cycle, regularly handle capacity loads or skull cracker ball, motor sizes must be materially increased to provide the fast speeds, rapid acceleration, and increased load due to increased allowances for impact and longer life of working parts. For this type of crane service, the crane builder should be furnished with a yard layout giving the approximate movements of hoist, trolley and bridge while unloading a car, moving the material within the yard, or making up cupola charges; this must also include the amount of material to be handled in a given time. This information will permit the design of a crane that will do the job with a minimum of down-time, and maximum dependability.

The capacity of the crane is determined by the weight of the magnet selected, Table 33, plus the weight of material to be handled as shown in Table 34. Except for the handling of billets and the skull cracker ball, allowance should be made in the capacity for a lift of nearly double the rated capacity at the instant the magnet is hoisted away from a pile of scrap, pig, or plates. The excess weight soon drops off and the magnet is hoisted with the rated capacity for the material involved.

As with the bucket-handling crane, the bridge design follows Section IX with the additional consideration of impact in the girders and additional clearance for the magnet in the vicinity of the cage. This clearance should not be less than 15". The trolley gauge (dimension K in clearances of Section VI) is not less than 6'-6" for a 39" diameter magnet, 7'0" for a 45" magnet, 8'0" for a 55" magnet, 8'6" for a 65" magnet, and 9'6" for a 80" magnet. Related dimensions will change accordingly. Provision must be made in the cab for the necessary magnet control equipment.

The magnet requires DC current for its operation. If the crane is operated from a DC power source, the addition of the magnet will present no problem except the addition of two bridge conductors. If the crane has AC power for operation, a source of DC power must be provided. Usually a motor-generator set or rectifier is mounted on the bridge footwalk for the DC power. If more than one magnet crane is operated on the same runway, it may be advisable to mount a motor-generator set on the building floor and connect its DC output to additional runway conductors.

The trolley should be adequate for severe service and able to accommodate larger motors. The mechanical brake is seldom used as no precision is required for lowering. An oversize electric brake of 150% motor torque rating should be provided. A cable reel of the spring, motor, or chain-driven type is required to take up the 2-conductor cable which carries the power from the trolley to the magnet. A double shoe or wheel collector should be furnished for the bridge magnet conductors and the main runway conductors so that in the event of failure or poor contact of the collector, the load on the magnet will not be dropped in areas where safety of ground personnel may be involved.

For a magnet crane used in a duty cycle as outlined in Section V, Page 24, the size of the bridge and trolley travel motors should be calculated from formulae in Section IX and then multiplied by 1.5. The nearest available horsepower is then selected and all machinery parts designed accordingly.

Fig. 118 shows a magnet-handling crane in action.

The magnet circuit is opened and closed by a contactor which is controlled by a single-throw master switch mounted in the front of the cab, convenient to the hoist controller.

Fig. 118

The magnet is suspended from the crane hook by a chain sling and is connected to the power cable by means of a plug and socket fixture. The magnet may be quickly disconnected and the hook used for other classes of loads. The crane may also be arranged to handle a motor-operated clam-shell bucket which would result in a versatile piece of equipment especially adapted to foundry yard service. This service requires that the block be equipped with a hook safety latch to secure the sling to the hook and a hook lock to prevent rotation of the hook in relation to the block.

Table 33 — Magnet (welded type) Dimensions and Data

Nominal Diameter In Inches	Weight in Lbs.	Head Room Required	Average Current In Amps @ 230 V.	Generator KW Capy.	Rectifier KW Capy.	B&S Wire Size for Magnet Cable
29	1390	2′6½″	11.5	3	5	8
39	2900	3′5″	18.2	5	6.5	8
45	3900	3′6″	33	10	11	8
55	7100	4′0″	46	15	16.0	6
65	10400	4′6″	65	20	22.0	4
80	17000	5′1″	120/87	35	44.0	1

Table 34 — Magnet Capacities

Average (all day) lifting capacity in pounds.*

Material lifted	29″	39″	45″	55″	65″	80″
Billet or slab	13,000	25,000	38,000	50,000	65,000	105,000
Skull cracker balls up to	8,000	12,000	16,000	20,000	30,000	45,000
Machine cast pig iron (Unloading cars including lean lifts)	550	900	1,800	2,500	3,500	7,000
No. 1 Heavy melting steel scrap (Sheet bars, crop ends, rail ends, etc.)	550	900	1,800	2,500	3,500	7,000
No. 2 melting steel (Plate scrap, auto frames, etc. cut to fit charging boxes)	450	700	1,150	1,600	2,400	4,200
No. 1 Machinery Scrap (Cast Iron)	400	600	1,000	1,250	1,650	3,600
No. 2 Busheling (Cut hoops, cotton ties, sheet, etc. Lighter than No. 12 gauge)	175	300	600	900	1,250	2,300
Plate punchings	350	600	1,000	1,550	2,400	3,600
Steel Turnings	175	300	500	800	1,200	2,500

*These are conservative lifting capacities based on an average of the lifts obtainable under average conditions and after the magnet has reached the maximum temperature it will attain on an all-day cycle of half-time excitation. When magnets are not operated continuously, or when material is stacked uniformly, the lifting values will be considerably higher.

LUMBER HANDLING CRANES

Lumber handling cranes qualify as special purpose cranes because of their extremely high bridge speeds and the special design of the trolley. These cranes usually have a bridge speed of from 600 to 1000 FPM which is 2 to 3 times that of standard industrial cranes. This speed requires special attention to size of bridge motor, gear drives, and trucks. The design of girders must include the high lateral forces which, because of the long spans, require much wider cover plates and stiffeners to provide for severe acceleration and deceleration forces.

Since these cranes are always handling the same product, the trolley is designed with special reeving to engage and keep stable a special grapple which handles stacks or packages of lumber usually of 4 to 8 tons weight. The cranes would be rated 5 and 10 tons to include the weight of the grapple. This grapple usually has two motors, one to rotate the load, and the other to open and close the arms which engage the underside of the load. When only one motor is used, it rotates the load and the opening and closing of the arms is done by a floor-man. The two-motor grapple permits one-man handling of the entire transportation of the stacked or packaged lumber.

The cab of a lumber handling crane is generally attached to the trolley so that the operator is close to his work and his vision is not interrupted by long rows of stacks of lumber that may be extremely high in certain locations within the storage or processing area. The cab may overhang the idler girder, or be of narrow construction and placed between the girders. Design of cab must not reduce end travel of the trolley any more than is necessary.

Fig. 119 shows a typical installation of crane, grapple and lumber storage method; note how lumber can be piled to a considerable height automatically by inserting spacing blocks between packages so that arms of grapple can engage or disengage a load.

Fig. 119

LOCOMOTIVE HANDLING CRANES

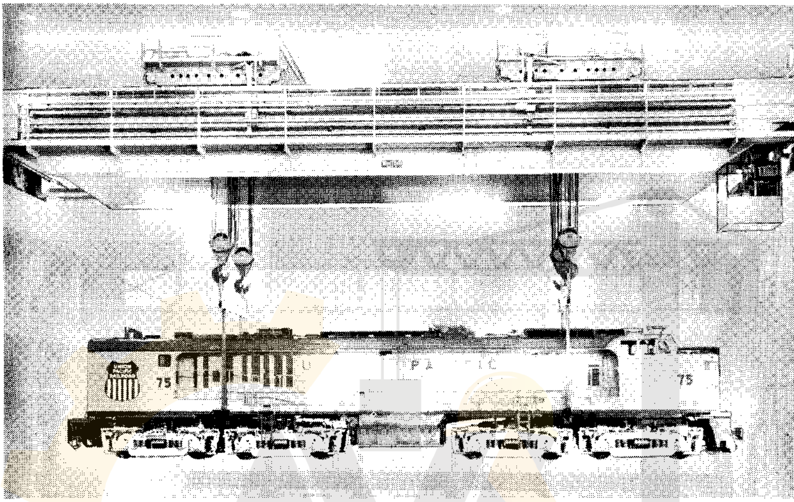


Fig. 120

The system of lifting an entire locomotive complete with all wheels, Fig. 120, with two special design trolleys has been utilized for the handling of large diesel units of today. A special lifting beam engaging each end of the unit can be reeved into a trolley so that the load may be lifted between the bridge girders, with the top of the unit being raised close to the trolley load-girt.

Another type of lifting beam incorporates long hooks that extend from the beam and engage lifting pads on the side frame of the locomotive unit. The lifting beam is reeved directly into the trolley and therefore eliminates the height usually taken by a conventional block and hook. This design reduces the overall height of the building necessary to accommodate a given lift.

These cranes have slow to medium speeds and therefore present no unusual design conditions for the use of standard crane components. Capacities range from 100 to 300 tons.

CUPOLA-CHARGING CRANES

Cupola-charging cranes of different types as shown in Section II, Pages 9 and 10, are classed as special purpose cranes adapted to foundry applications. The selection of a type for a given installation depends largely on the structural arrangement and floor plan in the vicinity of the cupola. The most popular type is the underslung charger, Fig. 121, which is adaptable for use under a variety of conditions.

The capacity of charging cranes is from 1½ to 7½ tons. High speed hoists are desirable to accommodate the usual high lifts from yard level to cupola charging opening. They must be rugged in design for dependable service.

You will note in Section II that all types of cranes are used in conjunction with the wishbone charging system. This wishbone may be installed in the cupola or be a part of the charging trolley and operated by a retriever mechanism to project it when making the actual charge into the cupola and retract it upon completion of the

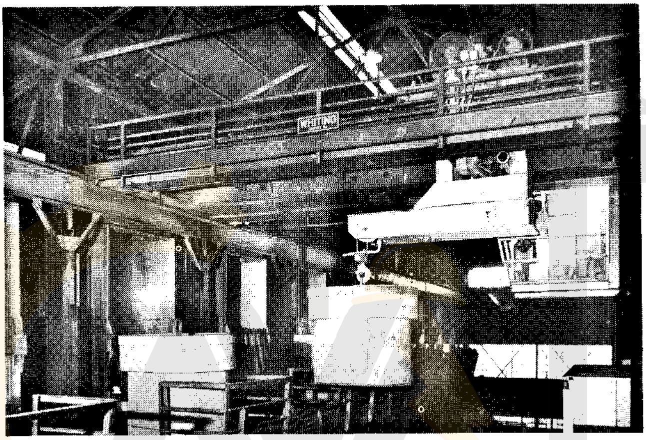


Fig. 121

charging operation, which permits the lowering of the cone and bucket shell to the loading level.

The wishbone charging system and cone-bottom buckets, Fig. 122, do a job mechanically that formerly could be done only by the best hand charging practice. The charge is distributed evenly around the periphery of the cupola, more open in the center; thus, the blast distribution and gas flow are more uniform, resulting in maximum temperature from minimum coke, and minimum oxidation. This method also eliminates the severe shock which results from quick release of the charge.

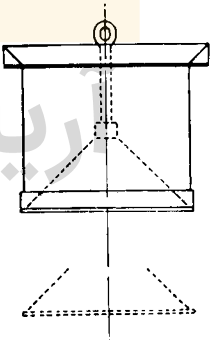


Fig. 122

The bucket consists of a cone bottom and center stem from which the entire weight is suspended, and a floating shell flanged at the upper edge. The wishbone permits the cone to be lowered slowly while the shell remains stationary, giving controlled dribbling of the bucket contents into the cupola.

In some installations, the scrap to be charged is of such size and shape that the cone-bottom bucket cannot be used. In such cases a controlled discharge drop-leaf bucket is recommended for use with a crane in the charging system.

The size of the bucket depends on the diameter of the cupola and the weight of the charge. Old and new installations of charging units vary so greatly that it is impossible to give standardized dimensions and layouts. If you are contemplating new cupolas to be served by high speed mechanical charging units, or if changing present methods or layout, refer your problems to an experienced builder that maintains a special department to solve and simplify your foundry problems. Monorail or skip hoist chargers may be more economical in original cost and operating cost in smaller installations and would be recommended over the more elaborate crane system.

Other special purpose cranes include: paper roll handling, Fig. 123, with its motor-operated clamping grapple or its lever-operated grip; wire reel handling, Fig. 124, with the 2-motor grapple that rotates and has arms that move in and out to engage the axis for different width reels; brick handling, Fig. 125, with the special brick grapple or tong and plate handling, Fig. 126. Cranes with two trolleys, Section II, Pages 7 and 8 are especially adapted to the easy and safe handling of long loads, Fig. 127.

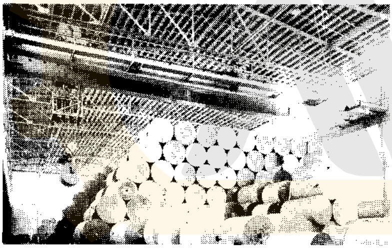


Fig. 123

Fig. 124

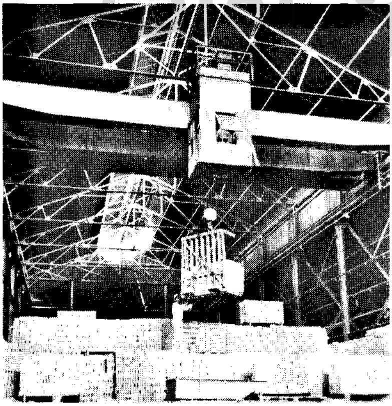


Fig. 125

Fig. 126

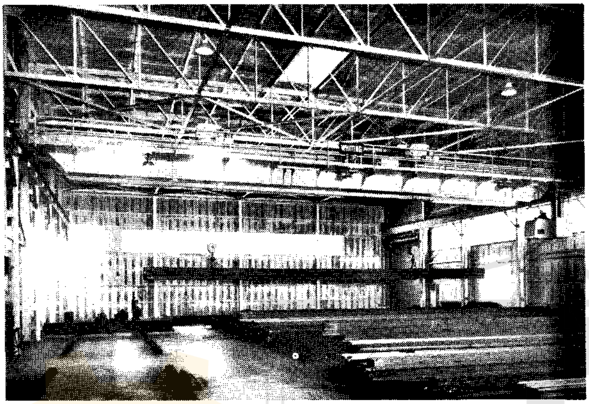


Fig. 127

SECTION XII — OTHER TYPES OF CRANES

A. — GANTRY CRANES

Gantry cranes are adapted to applications where overhead runways would be very long, costly to erect, and difficult to maintain alignment; or where such runways would interfere with handling operations, storage space, or service area. Also, where the track is not considered permanent, a gantry crane has the advantage of allowing a change in location without much trouble or expense. It is compara-

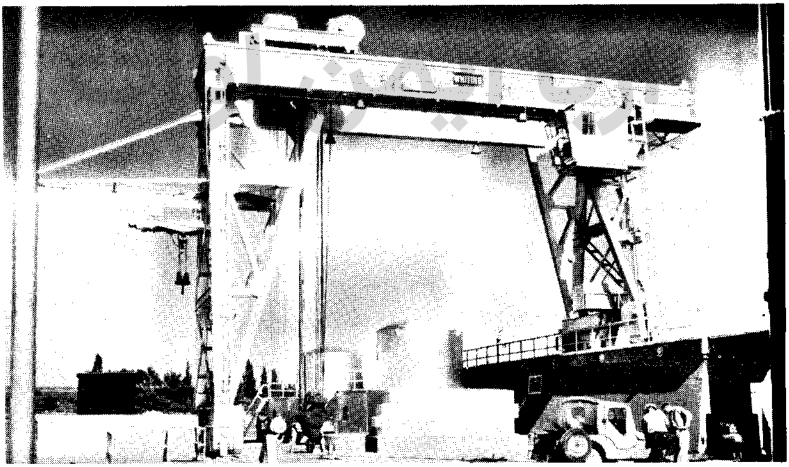


Fig. 128

tively easy and inexpensive to extend the length of the runway and thus increase the working area of the crane. Gantries are also common in situations were the crane itself does little or no travelling, but the transfer of materials is sideways and may be handled almost exclusively by the trolley.

Most gantry crane installations are outdoors, where there are no building restrictions within the service area.

Fig. 128 illustrates a gantry in hydro-electric dam service, and Fig. 129 shows a gantry in the steel industry handling long rails and beams by means of a special trolley.

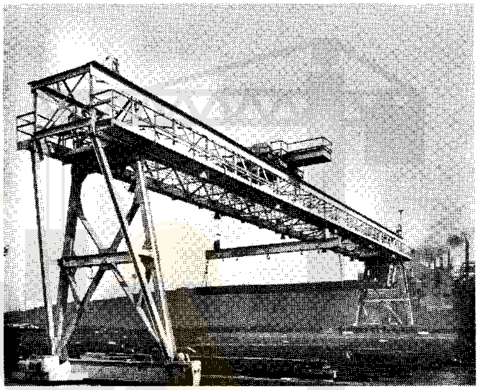


Fig. 129

The different types of gantry cranes are shown in Section II, pages 10, 11, and 12. A brief description and use for each design follows:

DECK-LEG: Gantry bridges of this design are quite common and found extensively in railroad yards, material storage yards and hydro-electric power plants. The legs are tied together beneath the girders, forming a platform or deck upon which the girders are mounted, Fig. 130. Trolley travel is limited to traversing the span distance between the legs or runway tracks. For cranes under 100'0" span, this construction is the most economical.

Fig. 130

THROUGH-LEG: For handling loads outside the area bounded by the crane runway tracks, a cantilever extension may be used, which necessitates a through-leg construction. This extension may be on one leg, Fig. 131, or both legs, Fig. 132, as the application may require. In this

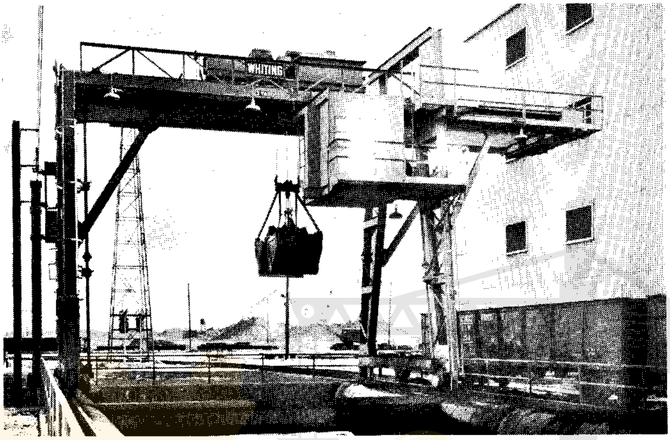


Fig. 131

Fig. 132

design, the outside uprights of the legs extend upward beyond the girders and are tied together at the top with a horizontal member, leaving sufficient clearance below for the passage of the trolley. An alternate design eliminates the overhead member and depends on the lateral strength of the girders plus the end girder connections to provide the required rigidity. In addition to the uses for deck-leg gantries, these cranes are invaluable in stacking and tiering materials in storage and shipping yards. This design may also be used to reduce the length of span between supporting legs, thereby reducing the girder section required and in turn the dead weight of the crane.

SINGLE-LEG: This design is used in those installations where it is convenient to have one end of the bridge supported on an overhead runway rail and the other end on a gantry leg of the deck or through-leg, Fig. 133, type. Advantages of this design are the utilization of existing adjacent building walls or the combination of runway and retaining wall for the storage of bulk material at the extreme of trolley travel eliminating covering the crane track or interfering with the travel of the bridge.

LUFFING BOOM: Where the length of effective runway may be curtailed by obstructions outside the crane span and where an overhang

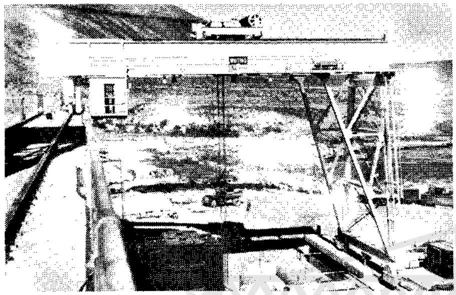


Fig. 133

Fig. 134

is necessary to serve an unloading track, a special design as shown in Fig. 134 may be used. This crane is equipped with a hinged cantilever extension that can be raised and lowered by a luffing-hoist, controlled by crane operator. Again this crane may be single or double leg with cantilevers of the fixed or hinged type at either or both ends of the crane.

STATIONARY: In those installations where only trolley travel is required to transfer loads sideways, a stationary gantry bridge may be used. This crane may be of the deck or through-leg type and is especially adapted for use at loading docks.

GATE-HANDLING: The major hydro-electric developments of recent years require special gantry cranes for gate-handling and for installing and servicing the power plant equipment, Fig. 135 and 136. These cranes are usually made to purchaser's specifications and are classified as special purpose cranes.

The design of gantry cranes follows the information and formulae given in Section IX with the following additional considerations:

GIRDERS: Because most gantry cranes operate out doors, special care must be taken in the selection of the type of girder to be used. A wind load of 30 pounds per square foot applied to the projected area of the girder must be added to the loading conditions described on page 57 for the lateral stress computations. The use of latticed girders must be explored so that dead weight is reduced to a minimum and

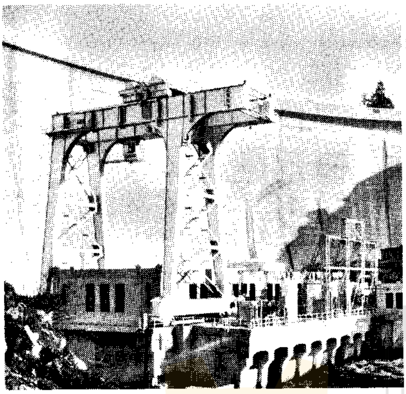


Fig. 135

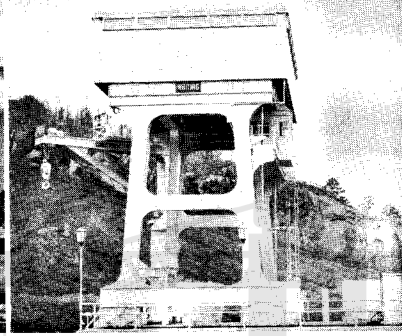


Fig. 136

the projected area exposed to the wind is held to a minimum to reduce lateral girder stresses, bridge motor horsepower and to increase the stability factor of the crane.

The overhang of the girder must also be checked to make certain that the stresses in the cantilever section do not exceed those in the span.

STABILITY: All factors, including dead weight, all possible positions of trolley and load, lateral forces and a 30 pound per sq. ft. wind acting on all exposed surfaces, that tend to produce an overturning moment must be found in checking the stability factor. The sum of the moments tending to produce overturning of the structure divided by the forces resisting that overturning is called the stability factor and the ratio should not be less than one over one and a half. In the case of excessive cantilever for short span cranes, it may be necessary to add counterweight or in cases of great height of legs it may be necessary to increase the wheelbase of the trucks.

LEGS: The gantry legs are built to develop high strength and rigidity without excessive weight. Economical sections are built up of beam and channel uprights braced with angles and diagonals for stiffness and connected to the girders by diagonal braces and horizontal gusset plates. Box section legs with stream-lined gussets are being specified to match the architecture of the immediate area.

TRUCKS: These are fabricated of wide flange beams, or built-up sections of plates and angles or plates in box section with a wheel at each end. Where the wheel loads are high, 2-wheel or 4-wheel equalizing bogie trucks are used, each gantry leg being supported by two trucks, Fig. 137. A 4-wheel truck permits the gantry to operate on a double track laid on filled or uneven ground, Fig. 138. The truck wheels should be provided with roller bearings and of a design as described on page 65. Straight tread wheels with ample tread clearance should be used throughout to avoid the thrust in the leg structure that would be introduced by the tapered tread. To prevent crane movement due to strong winds, a mechanical lock should be provided to securely clamp the truck to the rail or end stop when the crane is not in use.

Fig. 137

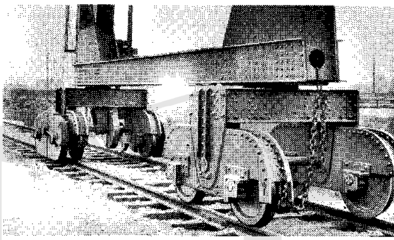


Fig. 138

Both the trolley stops and the bridge bumpers should be of the spring type to reduce shock and impact in the bridge structure.

DRIVE: Two designs of bridge drives are in common use. The original design consists of a motor coupled to a gear reducer at center of span. A horizontal cross-shaft connects this reducer to bevel or mitre gears in gear cases at the gantry legs. Vertical shafts at each leg transmit the power from the upper bevel or mitre cases to the lower bevel gear drives at each truck, Fig. 139. The bevel gear at the truck is directly on the wheel axle and produces the motion into the drive wheels. The cross and vertical shafting must be of ample size so that the wind-up is equal in both directions. The straight and true travel of the bridge depends upon the rigidity of the connecting shafting.

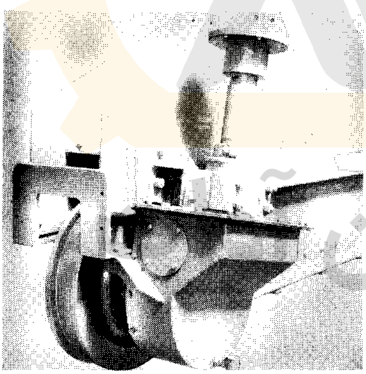


Fig. 139

A second design consists of individual motors and drive cases at one end of each leg of the crane. A cushioned paralleling of these motors must be provided to keep both ends of the crane travelling at the same speed regardless of loading condition. This design eliminates much mechanical equipment with its resultant maintenance due to wear.

The horsepower requirement of the bridge and trolley travel motors must be increased to accommodate the 10 pounds per square foot additional resistance produced by operation in a wind of 30 MPH. This is important and often doubles the size of motors required. The efficiency of additional bevel and mitre gearing must also be considered at approximately 97% of each gear case equipped with anti-friction bearings.

Hydraulic or electric brakes are used depending upon the cab location. If the cab is on the bridge, a hydraulic-electric parking brake is recommended so that the wheels will be automatically in a locked condition when the operator leaves the crane.

BRIDGE MISCELLANEOUS:

The following paragraph is taken from the United States of America Standards Institute Safety Code B30.2 pertaining to anchorage of outdoor cranes:

"Every outdoor crane shall be provided with secure fastenings convenient to apply and adequate to hold the crane against a wind pressure of 30 pounds per square foot. Where wind forces are anticipated to be in excess of 30 pounds per square foot special anchorage shall be provided by the user. Parking brakes where adequate may be considered minimum compliance with this rule. Preferably, another means of anchorage such as latches or crane clamps at the "home" positions, or automatic rail clamps for all positions, should also be provided by the user to supplement the primary braking system."

Footwalks shall be furnished as outlined in the overhead crane section and in addition gantry cranes shall be provided with ladders or stairways extending from the ground to the footwalk or cab platform.

TROLLEY: The trolleys used on gantry bridges are no different than those for overhead cranes. All combinations of main and auxiliary hooks, bucket, and magnet types may be used.

Because of the many combinations of design possible in the gantry crane field, no dimensions or clearance tables are shown in this handbook. If full information on your material handling problem is given a reliable crane builder, all necessary dimensions and wheel loading conditions will be furnished.

B. — CIRCULAR OVERHEAD AND GANTRY CRANES

The design of nuclear plants has created the need for a relatively new type of crane bridge; one that is an overhead or gantry type to run on a circular track as shown in Figure 140. These cranes range in capacities from 20 to 150 tons and run on a circular track on diameters of 48 to 125 feet. The trucks differ from standard units in that the wheels and axles are off-set to match the curvature of the runway rail. Individual drive units and motors are mounted at each end on diagonally opposite wheels. The runway collectors are located at the end of the bridge when the conductors are mounted on the runway beam or overhead when the conductor consists of a series of current-carrying rings. Girders, walkways, bridge conductors and trolleys are of the same design as described in Section IX.

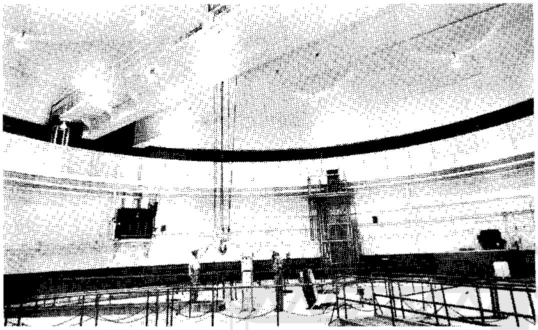


Fig. 140

C. – JIB CRANES

The term "jib crane" covers a design of crane that has a rotating boom attached to a mast that is held in a vertical position by floor and ceiling mounting or by wall-bracket mounting. Various types of these cranes are shown on pages 13 and 14. Capacities range from ½ to 15 tons and are designed to serve areas from 6 to 25 foot radius.

By handling material to and from machine tools, steam hammers, forging presses, and other production machines, these cranes relieve congestion and increase production, with only a relatively small investment required. These cranes relieve the overhead crane and eliminate unnecessary waiting time. They are particularly useful where the handling operations are of such duration and frequency that it would be impractical to tie up an overhead crane while performing them.

Jib cranes carry either electric hoists or chain blocks and are arranged for rapid manipulation by one man, usually the operator of the machine being served by the crane.

FLOOR AND CEILING MOUNTED: Jib cranes illustrated as types A, B, C, D and F on pages 13 and 14 are designed for 360° rotation. The type of bracing is dependent upon the required movement of the trolley, if any, in relation to the crane boom. All are composed of the vertical mast, a horizontal boom and the necessary bracing. The mast is held in position by bearings, one in a mounting attached to the ceiling or roof truss, and the other fastened to the floor. The thrust at each of these bearings is equal to the load in pounds times the effective radius divided by the distance between the floor and ceiling bearing centers. The weight of the crane must be considered concentrated at its center of gravity and the reaction added to each bearing live load.

WALL-MOUNTED: This crane is shown as type E on page 14 and represents the simplest and most economical design of all jib cranes. It is mounted on a building wall or column. The boom rotation is limited to approximately 180°.

SPECIAL PURPOSE: The spout hoist jib crane, Fig. 141, is a special design used in steel mills to handle the tapping spout at an open hearth furnace in the refractory-lining operation. Usually one crane serves two furnaces. This crane must be of rugged construction to withstand severe impact loads in the performance of its cycle of operation.

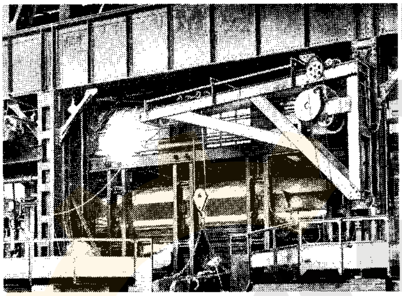


Fig. 141

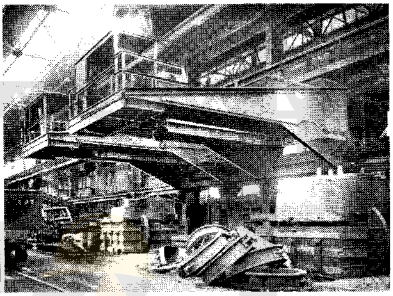


Fig. 142

Another special purpose crane is the travelling wall-bracket type, Fig. 142. This crane travels on a special runway and may be cab-operated as shown or floor-operated. It acts as an auxiliary crane to relieve the regular overhead crane. It finds special use in foundries and fabricating shops as it leaves the aisles free for use and does not require a track in the floor as is required for a single-leg gantry.

D. – PILLAR CRANES

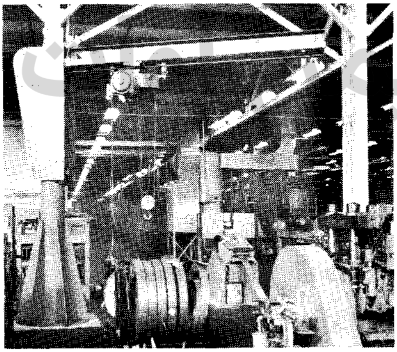


Fig. 143

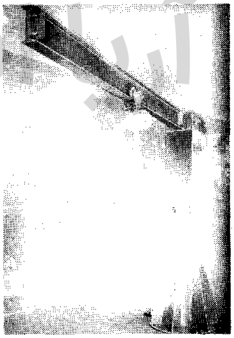


Fig. 144

Where materials are to be handled within a circle of not more than 45 feet diameter, it is practical and economical to specify a self-supporting jib with full 360° rotation, as illustrated on pages 14 and 15. These cranes range from ½ to 5 tons capacity in the type shown in

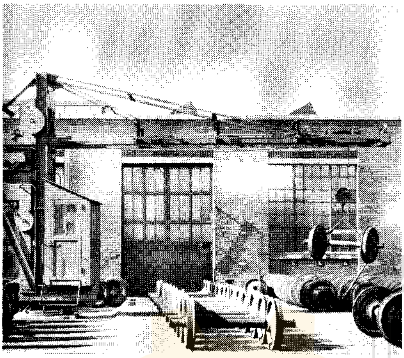


Fig. 145

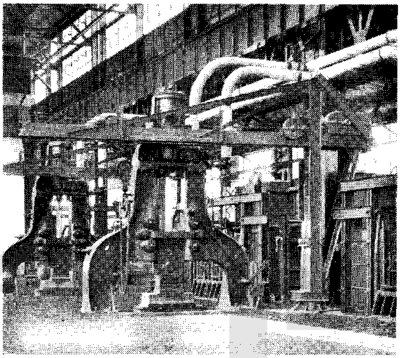


Fig. 146

Fig. 143. Other types may have capacities to 20 tons. They are used at machine tools or loading docks. All three motions: hoisting, trolley travel, and slewing (rotating) may be hand power or electrified or a combination such as electric hoist with hand power slewing and trolley travel. The electrified hoist is used in most installations. If 360° rotation is desired, a collector ring and pick-up must be installed to bring power from its source thru the rotating mast and boom to the trolley and hoist. Fig. 144 shows typical construction of floor-mounted pillar and lower mast bearing rollers for stability and ease of operation. Heavy duty pillar cranes are shown in Fig. 145 and 146.

E. — HANDPOWER AND ONE-MOTOR CRANES

Handpower traveling cranes find a very limited use in American industry today. They are falling into disuse because much manual labor and time are required to perform a prescribed operation. Speeds, especially those of hoist motions, are slow. With full load on the hook, one man can overhaul about 60 feet of chain per minute and exert an average pull of 125 pounds. A 15-ton load would require a hand chain travel of 445 feet for one foot of hook travel and require a constant pull of 100 pounds; thus a lift of 10 feet would require approximately 74 minutes with no allowance for rest or change of men. From this it is evident that too many man-hours would be required to do a job that an electrified hoist could do in 2 to 4 minutes.

Overhead cranes with capacities from one to fifteen tons may have the hoist power driven, keeping the trolley and bridge drives hand racked as these motions can be operated at a fair rate of speed with only nominal pull on the hand chains; such cranes are called "one-motor cranes".

To effect economies in design of hand power and one-motor cranes, wide flange beams with or without channels on top to give lateral stiffness are used for spans up to 60 ft. Because speeds are slow and impact negligible, l over b of beam girders may be as high as 50, and l over b of box girders as high as 60. Deflection of girders with full load at center of span may be as high as 0.015″ per foot of span. Box girders are usually used for spans greater than 60 feet.

To keep frictional losses to a minimum, hand powered cranes should be provided with anti-friction bearings for all drives and for bridge and trolley truck wheel axle bearings. Gearing need not be fully enclosed.

When span is greater than 70 feet the racking chains for bridge drive should either be near center of span or two sets of racking chains, one at each end of span, should be used with a man racking at each end. This keeps crane square on the runway and also reduces the work done per man.

Because of the limited use of this type of crane, we have omitted the table of clearances and data. This information can be obtained from standard catalogues of manufacturers of this type of crane.

F. – SPECIAL TROLLEY FOR LOW HEADROOM

The question of headroom required by an overhead traveling crane has been given a great deal of consideration and has led to the development of special designs, particularly for the smaller capacity cranes, which will operate in a surprisingly small overhead space and still provide good accessibility for maintenance. This design is ideal in an existing building with a low roof.

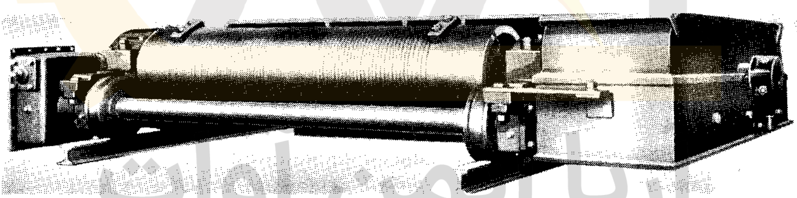


Fig. 147

An example of this construction is shown in Fig. 147. This trolley will fit the smallest space of any electric traveling crane of given capacity. Besides requiring minimum headroom, this trolley in 5-ton capacity, will permit the hook to approach within 20¼″ of the runway rail. On this same trolley the hook may be raised to within 23″ of the high point of the crane with 6″ additional lift for overtravel of the limit switch, making a minimum distance of 17″ from center of hook in highest position to high point of trolley. These same dimensions for a 10-ton capacity trolley are 20¼″, 2′11″ and 2′5″ respectively.

This special trolley is equipped with a mechanical brake and solenoid brake of the same general design as described in Section IX, Part B. It is compact and rugged, yet easily accessible. Roller bearings add to ease of operation and low upkeep. Gearing is completely enclosed in an oil-tight housing and operates in an oil bath. All bearings outside the gear housing are high pressure grease lubricated.

The danger of low headroom trolley lies in the fact that no provision is usually made for easy access to all machine parts for maintenance and replacement. The Hi-lo trolley described above is accessible and easily maintained. Because of this quality it is not an economical design and we have therefore designed a line of hoist-type trolleys for economy and these will be described on page 163.

G. – STEEL MILL CRANES

Recognizing the specific need for very rugged cranes for steel mill service, capable of 24 hours per day and 7 days per week reliable performance, the Association of Iron & Steel Engineers have, since 1910, sponsored a series of specifications defining the design requirements of electric overhead traveling cranes for steel mill service. The current A.I.S.E. Specification as of the publication of this handbook is identified as AISE Standard No. 6, revised May 1, 1949. This is obtainable from the Association. The present specifications represent much work and thought by a committee composed of steel mill engineers, crane manufacturers, crane equipment manufacturers, and members of research projects covering various phases of crane design.

To the crane builder, steel mill cranes are classed as "custom-made", and much design work and interpretation of specifications is expended on each order. The specifications are definite concerning material and how to use it according to formulae and experience which has been established. The final product and its performance is dependent upon the machining, fabricating and assembly practices and experience of the crane builder. This may have a great influence on the operation and maintenance costs of these cranes Dependability and ease of inspection and maintenance are all-important features of this type of crane.

One must realize that not all cranes used in a steel mill need be of a design as described above. There are many applications where a Class D or E crane will do the required job at a saving to the purchaser. The crane builder may use standard units detailed in Section IX with additional life factors and special safety requirements. It is the "mill specification" crane which will be described in the following paragraphs as it applies to cranes which have been built by Whiting Corporation.

BRIDGE

GIRDERS: Figure 148 shows a typical steel mill bridge. The design requirements governing loading, impact, allowable stress, deflection and torsion as outlined in the AISE Specifications are followed and result in a definite selection of cover plates, webs, vertical and hori-

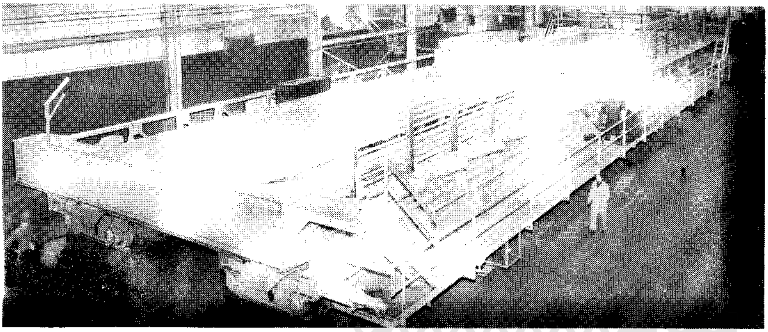


Fig. 148

zontal stiffeners in the girder design. In addition to heavier girders to meet the above requirements, the heavy control house, cab and machinery on the front girder requires a latticed auxiliary girder, Figure 149, securely tied into the rugged end girder connection for rigid support of these parts to prevent excessive deflection and girder twist.

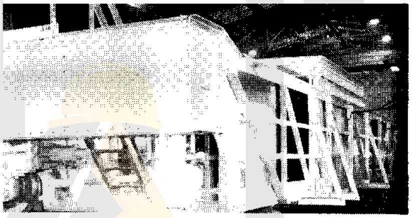


Fig. 149

TRUCKS, BEARINGS AND WHEELS: Wheels are rolled steel, rim-toughened, or case hardened for long life. Wheel loads are kept within standards that do not exceed Table 4 page 67. Wheel bearings are usually straight roller bearing on one side of the wheel and tapered or spherical roller bearings for thrust on the other side. The bearings are mounted in MCB or capsule housings that have large seats in the truck. Bearings are selected for long life as outlined in the specifications which may ask for minimum life of up to 40,000 hours.

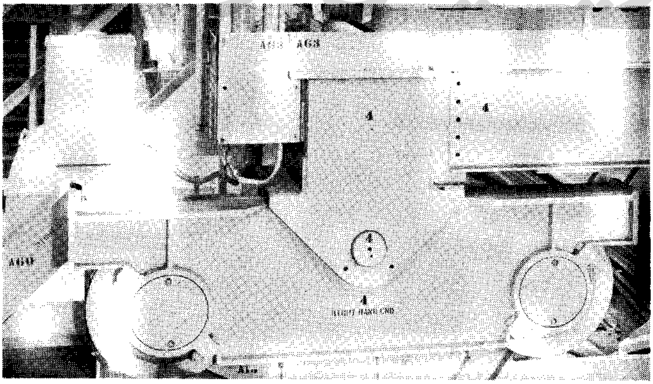


Fig. 150

The truck, plain or bogie type, is of welded design made from heavy plates and bars and rigidly reinforced with diaphragms and stiffeners. Safety lugs are provided to limit the drop of the truck in case of wheel breakage. Heavy safety fenders and spring bumpers are also provided. Figure 150 shows a typical truck assembly.

DRIVE: The drive, Figure 148, is designed for easy access to all components. Oil-tight gear cases near the trucks eliminate the troublesome reduction at the truck. Motor and brake is located at center of span. The cross-shaft is supported on anti-friction bearing pillow blocks and connected by safety flange or straight flange couplings, usually provided with face keys to take the shear off the connecting bolts. Because of the heavy construction and the fast bridge speed, very often, a drive is required on both girders. The bridge motors are then controlled by a duplex controller and the hydraulic brakes are operated by a single station in the cab.

The AISE specifications clearly define the design of gearing, bearings, shafting, couplings, fits on shafts, gear cases, covers and guards.

WALKS: Walks are required on both girders and must be of ample width to provide adequate working space around all machinery and control panels. A one-level walk is preferred and stairways and cross-walks with safety railings must be provided for easy access.

CONDUCTORS: Bridge conductors are of the rigid-type and consist of angles, tees, or bars supported at frequent intervals and well braced to prevent lateral movement or misalignment. They are usually located outside and above the back girder for easy maintenance as shown in Fig. 148.

CAB: Open cabs are provided with landing platforms and stairway from this platform to the bridge footwalk. The cab is enclosed with plate to a height equal to the railing height. Access gates are provided.

Enclosed cabs also have platforms and stairways. One type is large enough for the controls and operator and has an attached compartment in which all the control panels and resistors are located. Others are only large enough for the operator and controls, the panels and resistors being located on the footwalk. Figure 151 shows the interior of this latter cab and also the arrangement of master switches for a 5-motor crane.

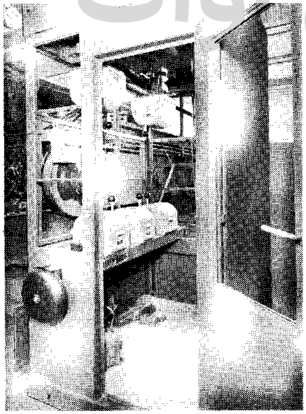


Fig. 151

Air-conditioning of crane cabs is gaining in favor. Some locations require this for operator comfort where high ambient air temperatures are prevalent. This system requires a tight, insulated cab equipped with double pane glass for maximum efficiency of the cooling unit.

TROLLEY

The AISE specifications go into considerable detail regarding the design of the trolley. Drums, sheaves, ropes, rope grooves and equalizers are well defined. Sheaves and drums shall be 30 times rope diameter if 6x37 rope is used and 45 times rope diameter if 6x19 rope is used. Equalizer sheaves shall be 18 times rope diameter. Gearing shall be figured as outlined with correction factors used to assure long life. Bearings are selected for long "minimum" life.

The trolley frame shall be welded rolled steel construction. Drum bearings and upper sheaves shall be so supported that the loads on the track wheels shall be equalized as much as possible. The frame shall be of the floored-over type with no opening except for ropes and magnet cables if required. Figure 152 and 153 show typical steel

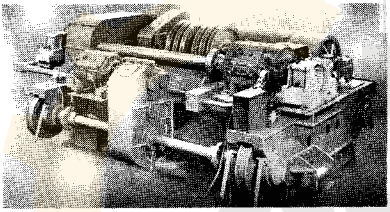


Fig. 152

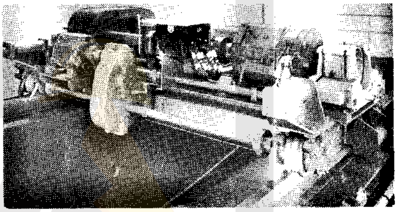


Fig. 153

mill trolleys with herringbone or spur gearing. A trolley with worm-gear hoist unit, Fig. 154, illustrates the extra equipment, such as cable reel, spring bumpers, and automatic lubrication, which are usually a part of a steel mill trolley.

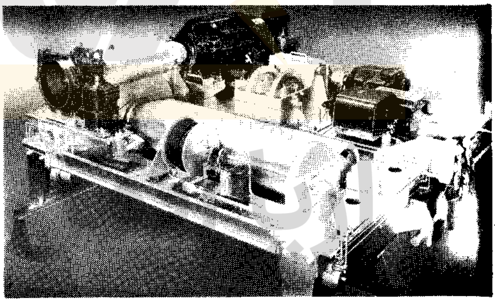


Fig. 154

TROLLEY DRIVE: Figure 155 shows a typical drive consisting of motor, gear-type flexible coupling, gear reducer, cross-shaft and guarded couplings connecting the cross-shaft directly to the wheel axle. Note the accessibility of all components and the safety features for maintenance personnel.

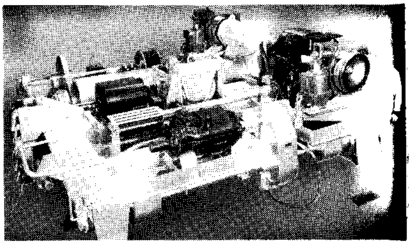


Fig. 155

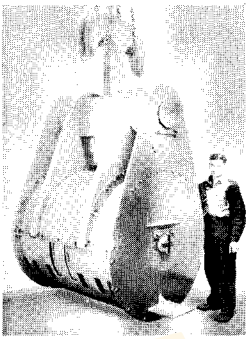


Fig. 156

LOAD BLOCK: Figure 156 illustrates the type of block required by the steel mills. Heavy plates enclose the sheaves and only small slots are provided for the ropes. This is a 125 ton block.

ELECTRICAL

All motors are of the totally enclosed mill-type. Provision must be made for the easy removal of the entire motor without disturbing other parts of the crane. The sizes of the motors should be calculated according to the formulae and tables of efficiency as given in the AISE specifications.

Controls should be of the full magnetic type with master switches in the cab and so located to give the operator maximum visibility of the hook load in the entire working area. The panels and resistors should be located as specified by the purchaser.

Brakes should be of rugged construction and of ample capacity to safely handle the loads and stop the crane motors.

Hoist limit switches must be of the dynamic braking type and so located that they are easily accessible for inspection.

Rigid standards for the wiring of these cranes have been established to prevent overheating with resultant burn-outs that would cause considerable down-time of such an important unit in the production of steel.

Although the AISE specifications give the basic designs to be followed, the interpretation of these specifications by the many different steel mill engineering departments make it difficult to establish standard clearances and wheel loads for the various capacities, spans and service conditions; therefore, no clearance tables covering steel mill cranes are included in this handbook.

H. – PRE-ENGINEERED "ER" CRANE

To bridge the gap between the standard industrial crane and the handpower or one-motor types, most crane builders have an intermediate line of cranes for E.O.C.I. specification No. 61 rated Class A, B, and C service. These cranes are a quality product that have been designed to meet a lighter duty than the rugged, heavier standard cranes. They are more economical in initial cost because the components have been standardized to such an extent that whole assemblies are made on a production basis and only the span, lift, and conductors should vary to suit the application. These cranes are not intended for use in a duty cycle operation but will give excellent performance in proper applications such as machine shops, paper mills, light warehouse duty, and light assembly floors. This line of cranes is available in capacities of 5 through 15 tons.

BRIDGE

GIRDERS: Bridge girders (under 60'0" Span) are wide flange beams that are specially reinforced to resist machinery torque and lateral forces produced by starting and stopping the crane. Reinforcement plates located inside each girder gives the torsional strength of an enclosed box girder. Girders are notched at the ends so that their weight rests vertically upon the bridge trucks. End connections and gusset plates are designed to keep the bridge square at all times.

Standard ASCE rails are mounted on the girder centerline. Trolley stops, welded to the bridge girder, prevent over-run.

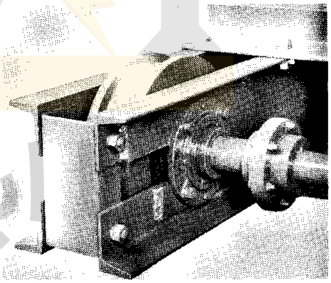


Fig. 157

TRUCKS: The structural trucks are double-channel steel construction with welded-in stiffeners and sufficient bracing to make a rigid one-piece unit. The truck to girder connection is made by large shelf angles and gusset plates to insure that girders will remain square with the trucks and thus prevent skewing on the runway.

Forged or rolled steel wheels with rotating axles are mounted on equally spaced double row, self aligning, flange mounted spherical roller bearings. Tapered tread wheels are used to assure free travel of the bridge on the runway. Wheel assembly is shown in Fig. 157.

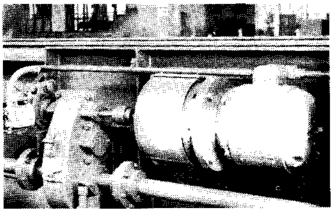


Fig. 158

DRIVE: The bridge drive consists of a fluid drive motor, gear reducer, disc or shoe type brake, safety flanged couplings, and a cross-shaft, Fig. 158.

A fluid drive permits the use of a squirrel cage motor and single speed control with the benefits of smooth, steady starts; stepless acceleration; motor protection against overloads and shock loads; simplified electrical controls; and the prevention of stalling the motor with heavy starting loads. For a more elaborate system, a wound rotor slip-ring motor may be used for a smooth stepped control at an increased cost.

A single, totally enclosed, oil tight case housing a two-reduction gear train is located at the center of crane span. The gearing is splash lubricated, precision-cut, steel. The output shafts of this gear case are connected by safety flanged couplings and a suitable cross-shaft, which is supported on ball bearing pillow blocks, directly to the truck axles; no gearing at the truck is employed.

For floor-controlled cranes, the bridge brake is a spring-set, solenoid or magnet released type rated at 50% of motor torque. For cab controlled cranes, a hydraulic brake is used.

Standard bridge speeds are 75-175 FPM for floor-operated and 200-300 FPM for cab operated.

TROLLEY

HOIST: The hoist unit consists of an electric brake, motor, mechanical brake, gear reducer, drum, rope, sheaves, block, hook, and limit switch. These component parts are made into an integral unit which is set between the trolley truck channels on a 3 point suspension system to prevent induced extraneous loads during assembly and conserve headroom. Ample clearances permit service to the hoist unit without removal from the trolley frame. This is an important feature of any crane and should always be investigated, See Fig. 159.

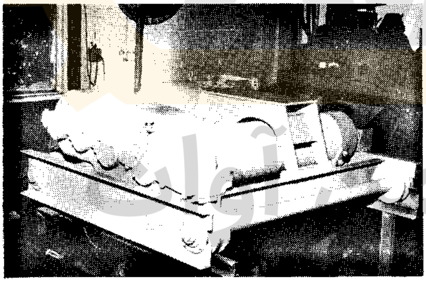


Fig. 159

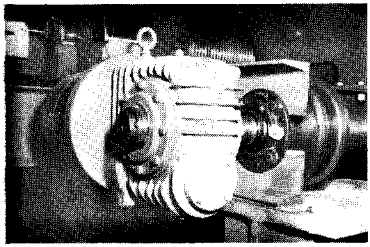


Fig. 160

The electric brake is a spring set, solenoid released shoe type rated at least 100% of the motor torque.

The standard foot mounted hoist motor may be wound rotor slip-ring, two speed-two winding, or single speed-single winding. It is connected to the gear case by the means of a flexible coupling.

The mechanical load brake is a Weston type, running in oil and built integral with the motor reduction gear set. It will hold the load independent of the electric brake as a double safety feature and permits safe lowering of the load under all conditions.

The gear reducer, incorporating anti-friction bearings throughout, consists of a three-reduction gear train in a totally enclosed, oil-tight split case. All gearing is splash lubricated, precision-cut steel mounted between bearings; no overhung gearing is used.

TROLLEY DRIVE: The trolley drive consists of a fluid drive motor connected by a NEMA flange to a right angle reducer shaft mounted directly to 2 wheels on a rotating axle and cross-shaft. Fig. 160.

TRUCKS: The single channel trucks are a part of the welded trolley frame. The driving cross-shaft is the axle on which forged steel wheels are mounted. The axles rotate in flange-mounted roller bearings, one at each trolley wheel.

ELECTRICAL EQUIPMENT

MOTORS: The hoist, bridge, and trolley motors are ball bearing, drip-proof, Class B insulated; crane and hoist duty motors designed for long life under full load. For economy and smooth control, a wound rotor slip-ring motor for the hoist, and squirrel cage motor with fluid drive for bridge and trolley is recommended.

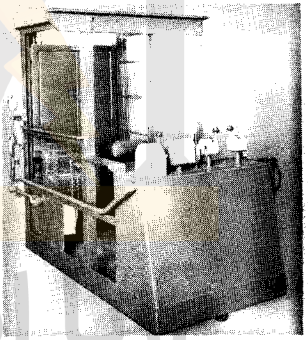


Fig. 161

CONTROL: Full magnetic controls are used to provide easy operation and minimum maintenance.

For floor controlled cranes, an 8 button push-button station is suspended from the trolley or from a fixed point on the bridge. At an increase in cost; a push-button station may be furnished on a messenger track system across the full length of the bridge span. This push-button station can be operated across the span of the bridge independent of the trolley location. One button is provided for each direction of motion of the hoist, trolley, and bridge; the buttons automatically return to a neutral position with the release of pressure. A Stop and Start button is also provided to engage or disengage the magnetic main line disconnect.

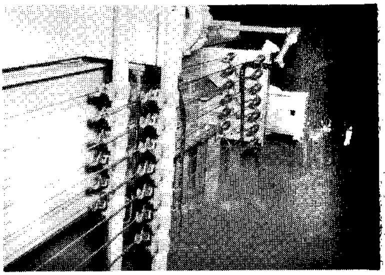


Fig. 162

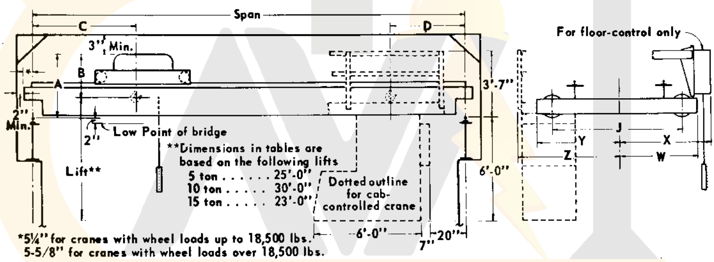
For cab control, Fig. 161, master switches are mounted in the front of the cab and arranged for maximum operator visibility and comfort. A safety switchboard is enclosed in a steel cabinet with cover so interlocked that it cannot be opened for inspections or fuse replacement unless the main safety switch is disconnected.

In either control system, 110 volts is used as the control voltage, assuring safety to the operator.

CONDUCTORS & COLLECTORS: These may be of the same types as described in Section IX. Bare copper wire conductors and bronze shoe collectors are standard equipment on these cranes, Fig. 162.

WIRING: The same rigid standards covered in Section IX, Part C, are maintained.

STANDARD DIMENSIONS AND CLEARANCES



Floor or Cab Control								Floor Control				Cab Control			
Capacity	Span	Rail	A	B	C	D	J	X	Y	Max. Whl. Load	Total Wt. of Crane	W	Z	Max. Whl. Load	Total Wt. of Crane
5	25	30	3-11	4-7	2-6	3-0	7-2	5-2	4-7	7,700	8,900	4-4	5-8	9,100	10,900
	30	30	3-11	4-7	2-6	3-0	7-2	5-2	4-7	8,200	10,300	4-4	5-8	9,700	12,600
	35	30	4-1	4-7	2-6	3-0	7-2	5-2	4-7	8,700	11,800	4-4	5-8	10,300	14,400
	40	30	4-4	4-7	2-6	3-0	7-2	5-2	4-7	9,000	12,700	4-4	5-8	10,900	15,700
	45	30	4-4	4-7	2-6	3-0	7-2	5-2	4-7	9,600	14,800	4-4	5-8	11,600	18,000
	50	30	4-4	4-7	2-6	3-0	7-2	5-2	4-7	10,500	18,200	4-4	5-8	12,700	21,700
	60	30	4-4	4-7	2-6	3-0	8-7	5-6	5-0	12,100	24,400	5-5	6-1	14,600	28,400
10	25	40	4-1	4-7	2-6	3-0	8-7	5-10	5-4	13,500	11,600	5-1	6-4	14,800	13,700
	30	40	4-4	4-7	2-6	3-0	8-7	5-10	5-4	14,100	13,000	5-1	5-4	15,600	15,300
	35	40	4-7	4-7	2-6	3-0	8-7	5-10	5-4	14,700	14,900	5-1	6-4	16,300	17,400
	40	40	4-7	4-7	2-6	3-0	8-7	5-10	5-4	15,100	15,900	5-1	6-4	16,900	18,800
	45	40	4-4	4-7	2-6	3-0	8-7	5-10	5-4	15,800	18,500	5-1	6-5	17,800	21,700
	50	40	4-1	4-7	2-6	3-0	8-7	5-10	5-4	16,300	20,300	5-1	6-5	18,500	23,700
	60	40	4-7	4-7	2-6	3-0	8-7	5-10	5-4	18,300	28,100	5-1	6-5	20,900	32,400
15	25	40	4-4	5-2	2-6	3-0	9-1	6-1	5-7	18,800	14,300	5-4	6-7	20,200	16,400
	30	40	4-7	5-2	2-6	3-0	9-1	6-1	5-7	19,700	16,600	5-4	6-7	21,300	19,000
	35	40	4-4	5-2	2-6	3-0	9-1	6-1	5-7	20,200	17,900	5-4	6-7	22,000	20,500
	40	40	4-4	5-2	2-6	3-0	9-1	6-1	5-7	21,400	21,500	5-4	6-7	23,300	24,500
	45	40	4-4	5-2	2-6	3-0	9-1	6-1	5-7	21,900	23,100	5-4	6-8	23,900	26,300
	50	40	4-7	5-2	2-6	3-0	9-1	6-1	5-7	22,700	26,100	5-4	6-8	24,900	29,600

I. — TRAMBEAM

Recognizing the fact that overhead material handling is an efficient means of lifting, stacking and transporting materials, but that crane runways are not always available or practical, the Whiting Corporation has developed a complete line of underhung monorail and crane equipment known by the trade name "Trambeam".

Trambeam systems are found in practically every industry including: Maintenance shops at mines and steel mills; production handling of wire and rods at mills and warehouses; commercial warehouses; steel fabricating shops; aircraft, automotive and railroad shops; foundries, ceramics, electrical manufacturing, textiles, tanning, paper, printing, chemical, furniture, aluminum, food processing and many others. These systems handle bulk materials in batches with buckets and all kinds of steel, aluminum, brass, copper, etc. in all forms: sheet, plate, bar, shapes, coils, and tubes by means of slings, magnets or special grapples. Packaged material, such as drums of oil, chemicals, etc.; boxes and crates of food and machinery, as well as bulky items such as jigs, fixtures, and dies, are all handled with equal ease.

Trambeam's versatility makes it ideally suited for many material handling applications. It can be designed to meet present needs and then readily changed or added to for future needs, thereby increasing present plant capacity without a large outlay of capital for new buildings. Its ability to interlock and transfer loads from bay to bay or area to area speeds production, reduces material handling time, and saves manpower. Its compactness provides maximum hook approaches to the sides and ends of the building as well as maximum lift for a given building height. This makes available the greatest floor area for work or storage and the maximum cubage for handling or storage. Equipment is overhead, out of the way of men and machines; materials are handled overhead so that no aisles need be provided and valuable floor space lost. All this keeps the original plant investment low and efficiency of operation high.

PLANNING FOR HANDLING EFFICIENCY: A complete analysis of the overall handling problem is the first step toward obtaining full efficiency from a Trambeam installation. This analysis should precede the plans for the plant building so that proper provision for supports and loading conditions can be incorporated in the design, thereby avoiding later revisions and costly remodeling. With a full knowledge of your entire problem, our engineers can recommend a complete system that will fulfill the following goals: (a) more production at lower cost, (b) maximum output, (c) shorter manufacturing cycles, (d) improved utilization of plant space, (e) steady production rates, (f) improved product quality, and (g) safety.

SELECTING TRAMBEAM EQUIPMENT: Upon completion of the analysis, the next step is the selection of a system that will do your

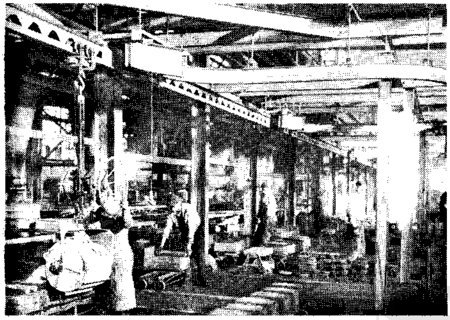


Fig. 163

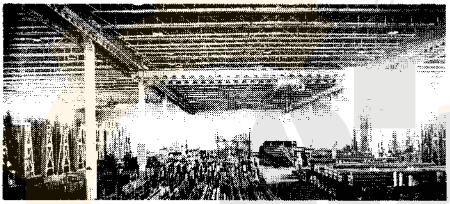


Fig. 164

particular job. There are two basic systems: (1) Trambeam monorail, providing line coverage for moving materials from point to point, with tongue or sliding switches, crossovers, turntables, lift or drop sections and track openers to increase handling flexibility, and with hand propelled or motor driven carriers, Fig. 163; (2) Trambeam cranes, hand propelled, hand racked, or motor driven, providing complete area coverage of an entire plant, with multiple runways, interlocks, fixed transfer sections and spurs to provide handling flexibility, Fig. 164. Both of these systems may be combined for maximum handling efficiency.

All types of loads up to 20 tons are handled at travel speeds up to 400 FPM as required by the cycle of operation. The efficiency of higher speeds is dependent on length of travel, with high frequency of use normally demanding greater travel speeds.

BUILDING CONSTRUCTION: In new buildings, columns, trusswork, and the location of all overhead obstructions, such as sprinkler systems, heating pipes and ducts, heaters, lights and electrical ducts, should be given special attention to provide for proper design loads and clearances for the Trambeam equipment selected for the job. Careful planning will assure structures of sufficient strength and reflect in lower costs of field installation.

In existing buildings, it may be necessary to relocate some overhead obstructions, reinforce existing structures, or add independent steel superstructures for the Trambeam installation.

TRAMBEAM DETAILS

FLEXIBLE SUSPENSION: With the center of gravity of loads well below the point of suspension, some sway and beam deflection is to be expected. However, Trambeam systems utilize a ball and socket suspension principle — at both ends of the hanger rods — which compensates for both sway and deflection. Ball and socket flexible suspension, Fig. 165, eliminates hazardous fatigue bending and possible crystallization in suspension rods. It places the major weight of the

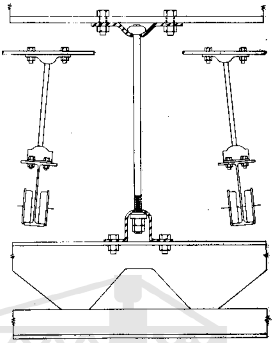


Fig. 165

load vertically on building members and assures equal distribution of weight on carrier wheels on both sides of the track. Flexible suspension, as utilized in Trambeam systems, also provides for possible misalignment of runways due to building settlement or other reasons because the suspension permits the crane to act as a gauge for center to center distance of runways. Should extreme settling of the building occur, the system is easily readjusted to level through use of the nut and thread arrangement without the use of shims and spacers. The overall result is easier load movement and absolute safety within rated capacities.

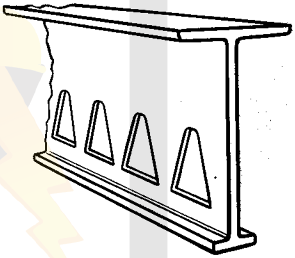


Fig. 166

TRACK: Trambeam is a composite beam section designed to provide a high strength, light weight suspended track member with a superior rolling surface. By combining a wide and thick top flange with a lower rail section of high carbon-manganese steel, Fig. 166, the maximum in compressive strength and lateral stability is obtained together with a hard non-peening rolling surface.

A number of standard sizes of Trambeam are manufactured. Light rail, which has a ⅜″ thick flange, is used on sizes 12″ and under; heavy rail, which has a ⅝″ thick flange, is used on sizes 12½″ and over. All beam sizes have a constant width of rail of 3¼″. The rolling rail sections are 55-65 carbon, 60-90 manganese steel especially rolled with a smooth flat rolling surface and to exacting tolerances. Hardness as rolled is 225 Brinell minimum.

Trambeam gives maximum life without peening and with minimum wear due to flanging. The operating surface is flat, providing an ideal surface for rolling wheels. The flat tread results in radial loading of wheel bearings, assuring maximum bearing life and minimum rolling effort. The action of the carrier wheels on the special high carbon rail continues to cold roll the rail surface all during the life of the system and provides for maximum life and ease of operation.

CARRIERS: A basic carrier consists of two two-wheel carrier heads, Fig. 167, mounted on and joined by a structural load bar.

All Trambeam carrier wheels are forged steel, induction hardened to 425 Brinell minimum and have flat treads. The wheels used on

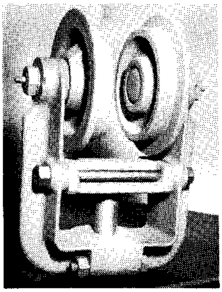


Fig. 167

lighter capacity carriers operate on ball bearings which are pre-lubricated and sealed to exclude dirt. The wheels used on all other Trambeam carriers operate on double row tapered roller bearings which are lubricated through readily accessible pressure fittings and are sealed to exclude dirt. Axles are of alloy steel, precision machined and ground.

The carrier head has two wheels mounted in a yoke which has a steel crossbar allowing the vertical pin, which is used to attach the carrier head to the load bar, to be supported at top and bottom for maximum strength. With the exception of the lighter capacity carrier heads, the yokes are split-type construction with heavy forged steel side frames permitting easy installation or removal anywhere in a system. On all carriers using carrier heads with split-type construction, self-aligning bushings are provided in the connection between the vertical pins and the load bar thereby assuring equal wheel loadings at all times and free swiveling action of the carrier heads which allows the wheels to follow the contour of the track thereby eliminating any tendancy for the wheels to bind or dig into the side of the track. Carrier heads with flangeless wheels and side guide rollers are available for heavy duty service conditions.

Trambeam carriers are used for handling and conveying loads and are available in a wide range of capacities to 40,000 pounds. Carriers may be attached directly to racks, buckets or similar conveying devices or may be equipped with hand or motor operated hoists depending upon the application. They may be hand propelled or motor driven depending on the travel distance and frequency of operation. Carrier heads should be used only in pairs, not individually.

Motor-driven carriers are identical to hand propelled units with the addition of a tractor drive for propelling the carrier. These tractor drives are available with a variety of motors and controls with the selection dependent upon travel speed, frequency of operation and load spotting requirements. Motor driven carriers are controlled from the floor by means of a pendant push button station or from a trailer type operator's cab.

TRAMBEAM CRANES: Trambeam cranes provide complete plant coverage and are available in any capacity up to 40,000 pounds. All Trambeam cranes are essentially the same in construction and vary only in capacity and span. They consist of a Trambeam girder fitted to end trucks which have two or more carrier heads, Fig. 168. The runways consist of at least two parallel tracks and as many additional parallel tracks as may be required to provide the desired area coverage. Cranes are generally of single or double girder construction. Triple girder cranes can be furnished to cover unusually long spans. Single leg and double leg Trambeam gantry cranes can also be furnished. Trambeam cranes may be hand propelled, hand racked or motor driven depending on the travel distance, frequency of operation and capacity.

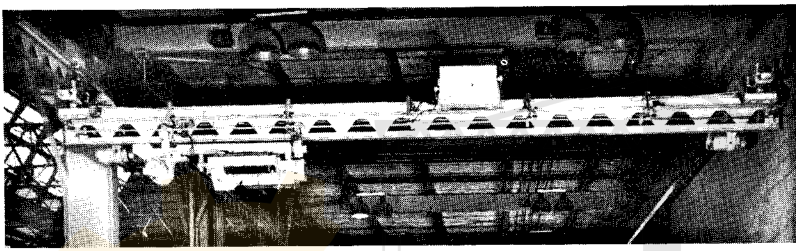


Fig. 168

Compression type connections between the end truck load bar and carrier load bars on 8 and 16 wheel end trucks incorporate a hardened self-aligning bushing assuring equal wheel loading at all times. On all 4 wheel end trucks using carrier heads with split-type construction, self-aligning bushings are provided in the connections between the carrier heads and the end truck load bar.

All Trambeam cranes except single girder cranes with low headroom connections may be equipped with interlock mechanisms and/or discharge points for transferring loads from area to area, either directly from crane to crane or by fixed transfer sections or spur tracks. Safety forks are provided on interlock mechanisms and discharge points which raise automatically to permit passage of the carrier when the interlock and discharge point are latched together. When the units are not latched, the safety forks prevent carriers from being accidentally run off the end of the bridge girder or discharge track.

Double girder cranes, Fig. 169, are generally used on systems incorporating long spans and where heavier loads are handled. They require a minimum of head room and for this reason are sometimes used on lighter capacity systems. The bridge girders are structurally framed together on the exact gauge of the carrier. This framing provides the necessary lateral stability to the bridge girders and maintains the gauge between the bridge girders.

Fig. 169

Triple girder cranes, Fig. 170, are generally used on systems having unusually long spans where the application advantage of a single girder crane is desirable. The crane consists of two load carrying girders suspended from the crane end trucks with a standard Trambeam bridge girder suspended from the load carrying girders. A single girder electric hoist carrier operates on the Trambeam bridge girder. Triple girder cranes may be used as transfer cranes by addition of standard interlock mechanisms and discharge points to the Trambeam bridge girder and permit the use of single girder spur tracks and fixed transfer sections.

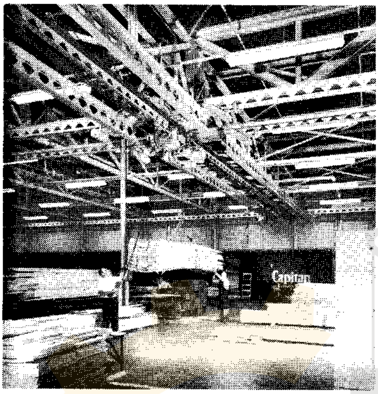


Fig. 170

Trambeam gantry cranes, Fig. 171, are generally used where no building structure exists for support of the usual overhead runways or where a single work area or group of work areas is to be serviced repetitively. One of the more common applications is the installation of single leg gantry cranes servicing individual work areas in the same bay in which an overhead traveling crane operates. The gantry cranes handle loads within their individual work areas permitting the use of the overhead crane exclusively for handling loads in and out of the individual work areas and for handling especially heavy loads over the entire bay. Gantry cranes may employ single or double leg construction depending upon the availability of a building structure to support an upper Trambeam runway. The bridge girders may be single, double or triple girder construction depending upon the span and load. The gantry leg end truck has double flanged wheels which operate on an ASCE rail rigidly installed in the floor. Single leg gantry cranes employ standard Trambeam end trucks on the upper runway which consists of flexibly suspended Trambeam track.

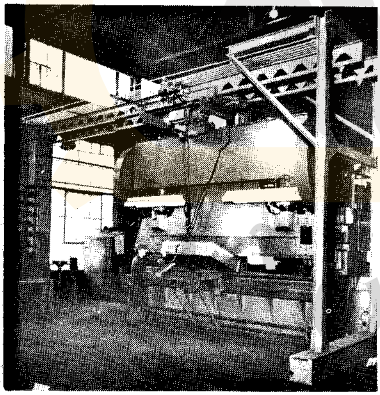


Fig. 171


Fig. 172

Trambeam stacker cranes, Fig. 172, provide an ideal solution to many types of material handling problems. Stackers normally operate in narrow aisles and provide maximum use of available cubic space, making them particularly well suited for warehouse handling. The stacker unit is mounted on a double girder carrier designed for this service which usually runs on a double girder Trambeam underhung crane. The basic elements of a stacker unit are a hoisting mechanism, a carrier with a rotating mechanism and a mast with fork carriage and forks suspended from the carrier. The mast may be of rigid, one-piece construction or, if it is necessary for the bottom of the mast to clear obstructions, it can be of telescoping construction. Traveling vertically on the mast is a fork carriage with a fork backing plate. Forged steel, adjustable type forks are normally furnished. The elements of lift, capacity, mast construction, fork construction, travel speeds and controls are determined by the requirements of each individual application.

When there is frequent starting and stopping of the crane or long travel distances, motor driven Trambeam cranes will increase the general efficiency of the system by enabling the operator to do more work in less time, with greater accuracy and without fatigue. Motor driven cranes are identical to hand propelled units with the addition of individual tractor drives to each propelling end truck. Two or more tractor drives are provided for the crane depending upon its length. These drives operate as individual units without mechanical connection between them and eliminate the necessity of a squaring shaft between end trucks. Individual drive units are not affected by normal wheel wear and, because they are not mechanically connected, are free to adjust for unequal pulls. Skewing of Trambeam cranes is virtually eliminated by the individual drives and any tendency to skew is adjusted quickly and automatically.

DRIVES: Tractor drives are used to propel all motor driven Trambeam carriers and cranes with the exception of double girder carriers having 4-wheel end trucks which are propelled by means of a modified tractor drive. Traction on all drives is obtained by polyurethane covered drive wheels bearing against the bottom of the Trambeam track. Pressure is applied to the drive wheels by heavy compression springs and is adjustable to provide the necessary traction to propel the unit and to compensate for any drive wheel wear.

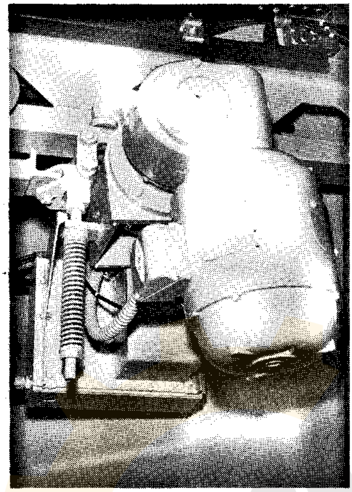


Fig. 173

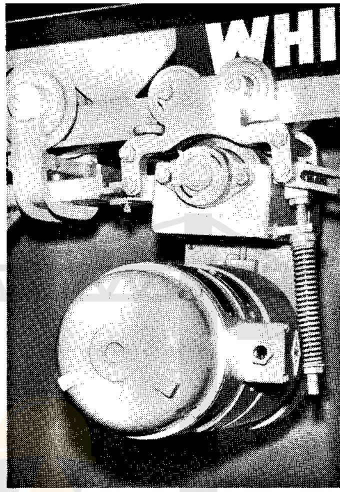


Fig. 174

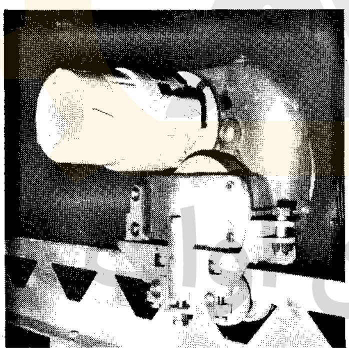


Fig. 175

To meet the wide range of service conditions, three tractor drives are available: Fig. 173 for light duty service; Fig. 174 for moderate duty service and Fig. 175 for heavy duty service. These drives are available with a variety of motors and controls with the selection dependent upon travel speed, frequency of operation and load spotting requirements.

The polyurethane covering on the drive wheels is a synthetic material which combines hardness, resilience and abrasion resistance to provide the finest traction wheel available today. It has exceptional wear characteristics, several times that of rubber, with a coefficient of friction about the same as that of rubber. It also has high tensile and tear strength and high load carrying capacity.

CONTROL: The motor control furnished on Trambeam motor-driven equipment consists of reversing magnetic starters usually operated by a push-button station for floor controlled equipment or master switches for cab controlled equipment. The three most frequently used control arrangements are: (1) all motions controlled from pendant push-button stations suspended from the carrier, or master switch control in a moving cab attached to the carrier; (2) as above except suspended from bridge; (3) bridge motion controlled from pendant push-button suspended from bridge with carrier and hoist motions controlled from separate pendant push-button suspended from the carrier. This equipment is sometimes controlled from a remote station or from a radio transmitter. There are many types of control available with selection depending upon the service, type of operations to be performed, speed and capacity.

Single speed control is generally used on light and moderate duty service applications where speed regulation is not essential. This control employs squirrel cage motors and provides one speed in each direction. An adjustable ballast resistor or internal fluid coupling may be used with the squirrel cage motors to provide gradual acceleration and is desirable when the speed is 100 FPM or more. The maximum speed recommended for single speed control is 200 FPM.

Two-speed control is used on moderate and heavy duty service applications where consistent speed regulation is essential regardless of variations in loads. This control employs multi-speed motors and provides two different speeds in each direction as desired. Internal fluid couplings may be provided on multi-speed motors to provide smooth acceleration and deceleration between the low and high speeds and is recommended when the high speed is between 150 FPM and 250 FPM. Two-speed control is available with a 3 to 1 speed ratio when fluid couplings are not used and with a 2 to 1 speed ratio when fluid couplings are used. The maximum speed recommended for two-speed control is 250 FPM.

Variable speed control is generally used on moderate or heavy duty service applications where heavy loads are being handled and selective speed control is required. This control employs slip ring motors and provides 3 to 5 speed steps in each direction. The low and intermediate speeds will vary depending on the weight of the load being handled. Variable speed control is always used when the speed is in excess of 250 FPM and on many slower speed applications where selective speed control is required. See Section IX-C for details of electrical.

HOISTS: The hoist assembly is a commercial unit arranged for mounting on Trambeam Carriers. It may be hand operated, motor operated or air operated depending upon the application. Most frequently used are motor-operated consisting of motor, gear reducer, electric and mechanical brakes, drum, cable, limit switch, block and hook.

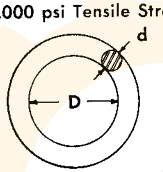
Motor-operated hoists may be single speed, two-speed or selective variable speed control with selection depending upon the service, type of operations to be performed, speed and capacity.

SECTION XIII
LIFTING ATTACHMENTS AND ACCESSORIES

Long experience in the application and operation of cranes has led to the development of lifting attachments and techniques which facilitate the handling of materials. A simple inexpensive attachment, designed specially for the work at hand, often is the means of greatly increasing the utility of the crane and speeding up the operations.

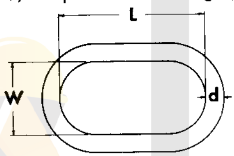
The simplest attachments are the ring, the pear-shaped link, the oblong link, the chain sling and the rope sling. To avoid their abuse, we are including explanations and tables as follows:

Table 35 — Ring Dimensions and Ratings (125,000 psi Tensile Strength)



Dimension d in.	D in.	Working Load Pounds
5/8	3	9,000
3/4	3	13,000
3/4	4	13,500
7/8	4	14,000
1	5	13,500
1 1/8	5	18,000
1 3/8	6	33,000
1 1/2	6	37,500
1 3/4	7	46,000
1 7/8	8	57,500
2 1/8	9	75,000
2 1/2	10	135,000

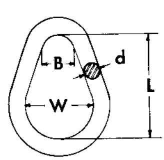
Table 36 — Oblong Link Dimensions and Ratings (125,000 psi Tensile Strength)



Dimension			Working Load Pounds
d in.	W in.	L in.	
1/2	2	4	4,550
5/8	2	4	9,250
5/8	2 1/2	5	4,550
3/4	2 1/2	5	9,300
7/8	2 1/2	5	12,000
7/8	2 3/4	5 1/2	11,200
1	2 3/4	5 1/2	16,500
1	3 1/2	7	15,800
1 1/8	3 1/2	7	19,500
1 1/4	3 1/2	7	25,000
1 1/4	4	8	24,000
1 3/8	4	8	28,000
1 1/2	4	8	32,000
1 1/2	4 3/4	9 1/2	35,000
1 3/4	4 3/4	9 1/2	41,000
2 1/4	5	10	55,000
1 7/8	6	12	48,400
2 1/2	7	14	92,000
2 3/4	8	16	116,000
3 1/4	8	16	155,000

Dimensions inches				Working Load Pounds
d.	B	W	L	
1/2	1 1/2	3	6	2,000
5/8	1 1/2	3	6	4,600
3/4	1 1/2	3	6	9,250
7/8	1 1/2	3	6	12,300
1	2	4	8	15,800
1 1/8	2	4	8	19,200
1 1/4	2	4	8	23,200
1 1/2	3	6	12	32,300
1 3/4	3	6	12	40,000
1 7/8	3 1/2	7	14	54,000
2	3 1/2	7	14	59,000
2 1/8	4	8	16	55,400
2 1/4	4	8	16	81,000
2 3/8	4 1/2	9	18	71,840
2 1/2	4	8	16	94,000
2 3/4	6	12	24	111,200

← Table 37 — Pear-shaped Link Dimensions and Ratings (125,000 psi Tensile Strength)



Chains find many uses in connection with crane loads and in conjunction with the rings and links in Tables 35, 36 and 37. Table 38 gives the safe loads for alloy steel chain.

Table 40 shows how to modify the safe load capacities for conditions where other than a single chain in a vertical position is used, and not shown in Table 38.

Wire rope slings are usually more convenient and versatile than chains. They are made of improved plow steel rope and are available with socket or thimble connections at the ring and hook. Table 39 gives the strength of slings as described. For the many other combinations of styles, end fittings and cable sizes, refer to catalogs of wire rope manufacturers where selections can be made to meet exact requirements.

Refer to Table 40 for safe load factor to be considered when using double slings for various loading conditions.

Table 38 — MAXIMUM WORKING LOAD LIMIT OF ALLOY CHAIN SLINGS

		Double Sling			Triple & Quadruple Sling		
	Vertical Angle (1)	30°	45°	60°	30°	45°	60°
Chain Size, Inches	Horizontal Angle (2) / Single Sling	60°	45°	30°	60°	45°	30°
$\frac{1}{4}$	3,250	5,650	4,550	3,250	8,400	7,300	4,900
$\frac{3}{8}$	6,600	11,400	9,300	6,600	17,000	14,000	9,900
$\frac{1}{2}$	11,250	19,500	15,900	11,250	29,000	24,000	17,000
$\frac{5}{8}$	16,500	28,500	23,300	16,500	43,000	35,000	24,500
$\frac{3}{4}$	23,000	39,800	32,500	23,000	59,500	48,500	34,500
$\frac{7}{8}$	28,750	49,800	40,600	28,750	74,500	61,000	43,000
1	38,750	67,100	54,800	38,750	102,000	82,000	58,000
$1\frac{1}{8}$	44,500	77,000	63,000	44,500	115,500	94,500	66,500
$1\frac{1}{4}$	57,500	99,500	81,000	57,500	149,000	121,500	86,000
$1\frac{3}{8}$	67,000	116,000	94,000	67,000	174,000	141,000	100,500
$1\frac{1}{2}$	80,000	138,000	112,500	80,000	207,000	169,000	119,500
$1\frac{3}{4}$	100,000	172,000	140,000	100,000	258,000	210,000	150,000

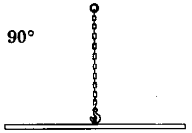
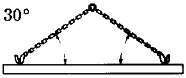
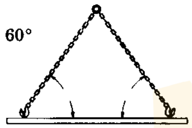
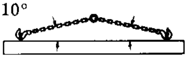
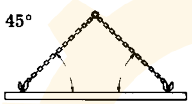
(1) Rating of multi-branch slings adjusted for angle of loading measured as $\frac{1}{2}$ of the included angle between the inclined branches at the master link.

(2) Rating of multi-branch slings adjusted for angle of loading between the inclined branch and the horizontal plane of the load.

Table 39 — Single leg sling capacities for 6 x 19 and 6 x 37 Improved Plow Steel Rope with Fibre Core

6x19 Rope Diameter	Safe Load Pounds	6x19 Rope Diameter	Safe Load Pounds	6x37 Rope Diameter	Safe Load Pounds
$\frac{1}{4}$	1,000	$\frac{5}{8}$	5,600	$1\frac{1}{4}$	19,600
$\frac{5}{16}$	1,500	$\frac{3}{4}$	7,800	$1\frac{3}{8}$	24,000
$\frac{3}{8}$	2,200	$\frac{7}{8}$	10,200	$1\frac{1}{2}$	28,000
$\frac{1}{2}$	3,600	1	13,400	$1\frac{5}{8}$	32,000
$\frac{9}{16}$	4,600	$1\frac{1}{8}$	16,800	$1\frac{3}{4}$	38,000
				2	50,000

Table 40 — Safe Chain or Rope Load for Various Loading Conditions

Loading Condition	Multiplier for Tables 38 & 39	Loading Condition	Multiplier for Tables 38 & 39
90° 	Safe Load x 1.0	30° 	Safe Load x 1.0
		20° 	Safe Load x 0.684
60° 	Safe Load x 1.732	15° 	Safe Load x 0.517
		10° 	Safe Load x 0.346
45° 	Safe Load x 1.414	5° 	Safe Load x 0.174

SPECIAL HOOKS, GRAPPLES & TONGS: Where cranes are used to handle the same size, type and shape of load, the addition of a special hook, grapple or tong may speed up handling. In many instances these devices can hook on and release the load without manual assistance, thus increasing the safety and economy of material handling.

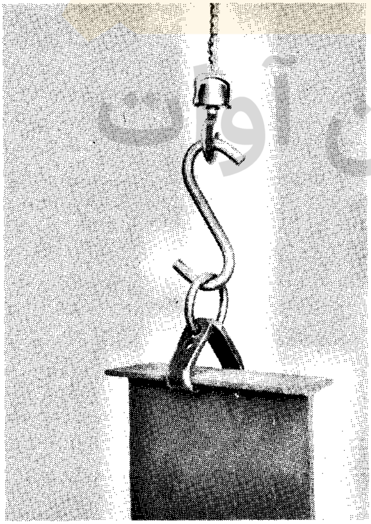


Fig. 176 — Beam Hooks

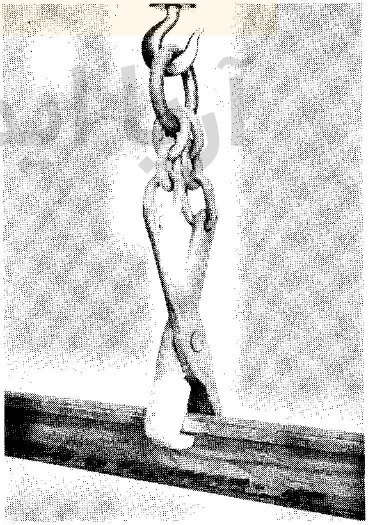


Fig. 177 — Rail Tongs

Fig. 178 — Plate Grip

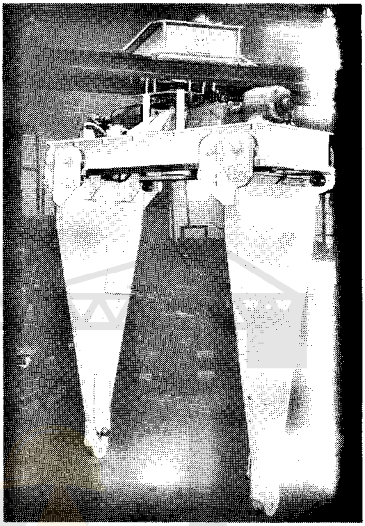


Fig. 179 — Reel Grapple

Bales, bars, barrels, beams, boxes, coils, pipes, plates, rolls, rails, reels and slabs are some of the items that can handled with greater economy and facility when special hooks, grapples or tongs are used. Figures 176, 177, and 178 illustrate some simple devices. Figure 179 shows a wire reel handler that turns and adjusts width by remote control. These devices are made by crane builders and other manufacturers to do a particular job for the user.

LIFTING BEAMS: Lifting beams usually are employed to lift single loads that exceed the capacity of one crane, where a second crane is available. They may hang from a single hook, or two-hook trolley and have a series of connectors on the bottom flange to handle long or flexible items. Gate lifting beams are essential in hydro-electric power plants and dams used for flood control.

VACUUM HANDLING — Whiting's Uni-Grip is a lifting attachment that handles steel, aluminum, glass, concrete, plastic, wood products and other materials with ease and safety without damage to the product being handled. Whiting's Uni-Grip is a below-the-hook lifting device which employs the forces of atmospheric pressure to handle materials safely, quickly, economically. It consists, basically, of two components; a power source, called Vac-Pak, and a gripper arrangement consisting of a single gripper or a loadbar with multiple grippers. In operation it converts atmospheric pressure into lifting power — simply by evacuating the air between the gripper or grippers and the material to be handled. The result is a perfect seal that will hold until air is forced back into the captive space between the gripper and the object being handled. Vibration or power failure will not break this seal.

Uni-Grip can handle virtually any material, in weights up to 2,000 lbs., to which a gripper can be attached. The six attachments that are currently available, plus the special loadbars that can be designed to your specifications, grant Uni-Grip a flexibility that is unsurpassed in material handling tools.

The economy is found in three areas: initial purchase price, which in most cases is below $1,000.00; operating costs, which invariably drop because Uni-Grip is a one-man operation; production, which invariably increases because of faster flow of material once slinging, hooking and related problems are eliminated. Units in operation are shown in Figures 180 and 181.

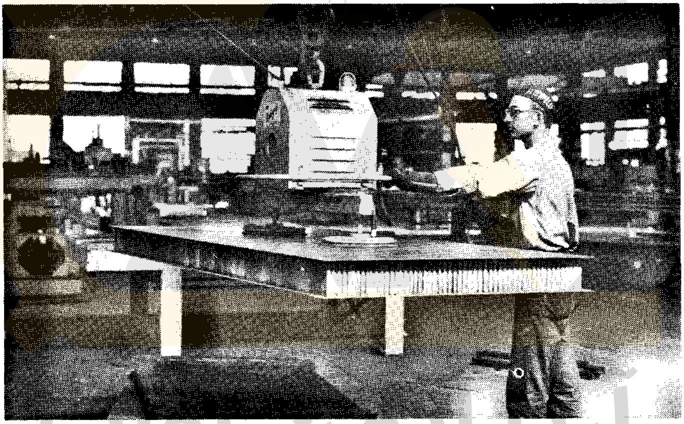


Fig. 180

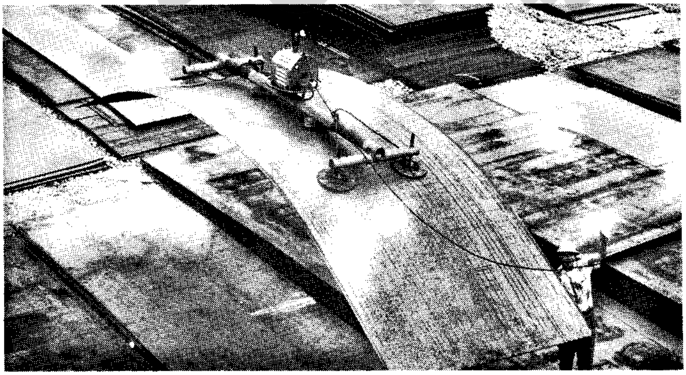


Fig. 181

WEIGHING EQUIPMENT: Cranes are often used over a shipping floor or process line where it is necessary to weigh the material handled. Instead of transporting the material to a fixed scale location and returning to the original point, it is now possible to add a weighing device to the crane hook, build it into a special block, or combine it with the upper sheave assembly of the trolley, thus saving much valuable crane time.

There are four types of weighing devices: (1) Lever system, consisting of a system of levers which actuate a dial indicator. (2) Hydraulic action in which the load is converted to hydraulic pressure and measured on an indicator or scale suitably calibrated to read in pounds. (3) Spring type in which the load produces a deflection of the springs that is measured and transmitted to a dial by means of mechanical linkage. (4) Load cell or strain gauge; the load action on a strain gauge is transmitted to a dial by an electronic device. By the addition of relays this system may operate a printing attachment that is capable of recording the weights without clerical effort.

OVERLOAD SIGNALS AND SWITCHES: For added safety, cranes may be provided with signal lights or warning horns that are actuated by devices which sense an overload on the crane hook. A more positive overload protection uses a micro switch and relay that cuts the power to the hoist motor when starting to lift an overload. In this case the hook must be lowered and the load reduced before further hoisting is possible.

SIGNAL LIGHTS: In addition to overload warnings, signal lights may be used to indicate when power to the crane is turned on.

Crane signal lights are used on crane runways for operator's instructions. They may also be used to indicate that the crane is in or approaching an area of restricted operation.

CRANE LIGHTS: Lights are placed on cranes to illuminate the working area over which the crane travels. These lights are mounted on a crane girder or walk in such a manner as to be easily accessible for inspection and replacement. Shock absorbing mountings protect the lights and help to obtain long lamp life.

SANDERS: Cranes operating under conditions of poor traction between drive wheels and rails can benefit from the installation of sanders. Although most traction troubles occur on out-door cranes due to rain, ice or snow, there are cases of traction difficulty with indoor cranes operating in moist or steam conditions. Sanders will effect a positive and economical solution to this difficulty. Sanders are operated remotely by electro-magnetic controls and provided with heaters to keep the sand dry and free-flowing.

CRANE CAB VENTILATING AND FILTERING SYSTEMS: Cranes may be operated in areas where dust or fumes are of such a nature or quantity as to produce objectionable or even dangerous working conditions. In these conditions, the crane operator can be protected by equipping the enclosed cab with a ventilating unit to provide filtered air. Provision may also be included for cab heating.

When cooling is required, an air conditioning unit may be used in a cab which has been designed and insulated for this purpose. A ventilating and filtering system can be added to most existing enclosed cabs, but the installation of an air conditioner requires a cab designed specifically for that purpose.

COMMUNICATION SYSTEMS: To facilitate the efficient use of cranes, communication systems are used in conveying instructions from dispatchers and floor personnel to the crane operator. These systems are of particular value in hydro-electric plants where operations are at different levels or in industrial plants where the movement of cranes is co-ordinated with other operations on a production line.

CABLE REELS: For cranes with magnets, motor-operated buckets, or other power-operated accessories on the hook, it is necessary to supply a conductor cable from the trolley to the hook. One end of this cable is usually attached to a cable reel, whose function is to automatically wind and unwind the cable in such a manner that it is kept taut at all times. The reel may be driven by self-contained springs or motors, or externally by chain and sprockets or gearing connected with the hoisting drum. The power supply is brought to brushes which make contact with collector rings at the end of the reel. The reels are equipped with the required number of brushes and rings to operate the equipment attached to the crane hook.

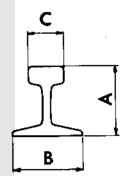
SECTION XIV
CRANE RUNWAYS & RUNWAY CONDUCTORS
CRANE RUNWAYS

The design and construction of crane runways may be divided into the following components: rails, beams or girders, beam supports, columns and foundations. The structural design is based on the wheel base and maximum wheel loads of the specified crane or cranes to be placed on each runway. This data is shown on pages 26 to 41 inclusive. For wheel loads not shown the computation on page 63 may be followed.

RAILS: Recommended rail sizes for different capacity cranes are given in the table of standard clearances, pages 26 to 41 and the rail sizes for wheel diameter and maximum wheel load are shown in Tables 2, 3 and 4, pages 66 and 67, according to class of service.

Table 41 — Dimensions of Rails

Type & Weight Per Yd.	A	B	C	Type & Weight Per Yd.	A	B	C
ASCE 30	$3\frac{1}{8}''$	$3\frac{1}{8}''$	$1\frac{11}{16}''$	ASCE 100	$5\frac{3}{4}''$	$5\frac{3}{4}''$	$2\frac{3}{4}''$
ASCE 40	$3\frac{1}{2}''$	$3\frac{1}{2}''$	$1\frac{7}{8}''$	Beth. 104	5″	5″	$2\frac{1}{2}''$
ASCE 60	$4\frac{1}{4}''$	$4\frac{1}{4}''$	$2\frac{3}{8}''$	U.S.S. 105	$5\frac{3}{16}''$	$5\frac{3}{16}''$	$2\frac{9}{16}''$
ASCE 70	$4\frac{5}{8}''$	$4\frac{5}{8}''$	$2\frac{7}{16}''$	U.S.S. 135	$5\frac{3}{4}''$	$5\frac{3}{16}''$	$3\frac{7}{16}''$
ASCE 80	5″	5″	$2\frac{1}{2}''$	U.S.S. 175	6″	6″	$4\frac{1}{4}''$
ASCE 85	$5\frac{3}{16}''$	$5\frac{3}{16}''$	$2\frac{9}{16}''$	Beth. 171	6″	6″	$4\frac{5}{16}''$
ASCE 90	$5\frac{3}{8}''$	$5\frac{3}{8}''$	$2\frac{5}{8}''$				



Rails should be arranged so that joints on opposite runway girders for the crane will be staggered with respect to each other and with respect to the wheelbase of the crane. Rail joints should not coincide with runway girder splices. 30, 40, and 60 lb. rails are available in 30 and 33 foot lengths; 70, 80, 85 and 100 lb. rails in 33 and 39 foot lengths; and the remainder shown in Table 41 at 39 foot lengths. Rails are furnished with standard drilling for commercial rail splices. Rails purchased for crane runways should be specified for crane service.

Rail joints may be bolted with standard splice bars or welded. Splice bars are furnished in various sections to match the contour of the rail web, base and head. It has been found that no provision need be made for expansion joints in the rail length. Provide for total linear expansion in the placing of end stops or rail-creep stops. To assure a smooth, reliable welded joint, careful control is required in all stages of the welding operation.

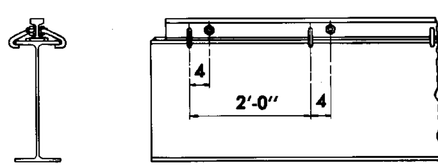


Fig. 182

Rails may be fastened to the runway with hook bolts, Fig. 182, bolted clips, Fig. 183, or welded, Fig. 184. Hook bolts are favored because the rail can be easily adjusted after installation and the beams need not be drilled during installation as is required for bolted clips. Welded clips are not recommended where it is probable that rails must be replaced or where settling and shifting of the runway may require re-alignment of the rails.

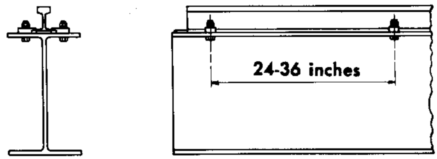


Fig. 183

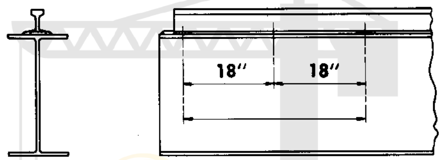


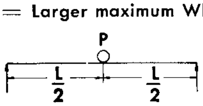
Fig. 184

BEAMS OR GIRDERS: The crane wheel load, crane wheelbase and distance between columns are the determining factors in selecting runway beams. For Class C, D and E service the wheel load should be increased 25% as an allowance for impact; for Class F, this allowance may be as high as 50%; and for Classes A and B, the allowance may be reduced to 15%. In addition to the vertical loads, a horizontal thrust (lateral force) equal to 10% of the hook load plus the trolley weight is assumed to act at the top of each rail at right angles to the runway and another horizontal load (longitudinal force) equal to 10% of the wheel loads is assumed to act at the top of the rail parallel to the runway. In localities subject to earthquakes, runways shall be designed with due regard for such conditions.

The maximum moment due to moving concentrated loads will occur under one of the loads when that load is as far from one end as the center of gravity of all the loads on the beam is from the other end.

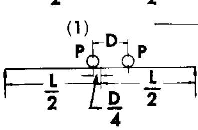
Table 42 — Bending moments for runway beams under various moving loads.
P = Larger maximum Wheel load — p = Smaller maximum Wheel load.

Case 1



Maximum moment $= \frac{PL}{4}$; L = span in inches.
Occurs under load P at middle of span.

Case 2

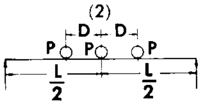


Max. moment $= \frac{2P}{L}\left(\frac{L}{2} - \frac{D}{4}\right)^2$ D = wheelbase in inches

Alternate formula $P\left(\frac{L}{2} - \frac{D}{2} + \frac{D^2}{8L}\right)$

Occurs under left (1) load.

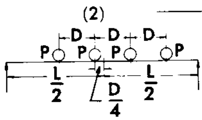
Use Case 1 if D $>$ .586L or if L is $>$ 1.7065D

Case 3 

Maximum moment = $P\left(\frac{3L}{4} - D\right)$

Occurs under middle (2) load.

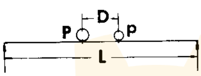
Use two loads as in Case 2 if D > .450 L

Case 4 

Max. moment = $P\left(L - 2D + \frac{D^2}{4L}\right)$

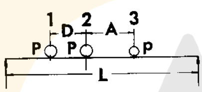
Occurs under load (2)

Use three loads as in Case 3 if D > .2682 L.

Case 5 

Max. moment = $\frac{P + p}{4L}\left(L - \frac{p}{P + p}D\right)^2$

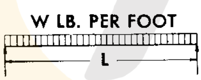
Occurs under load P

Case 6 

Max. moment = $\frac{p + 2P}{L}\left(\frac{L - \frac{pA - PD}{p + 2P}}{2}\right)^2 - PD.$

Occurs under load (2)

Max. moment may occur for two loads as in Case 2.

Case 7 

Max. moment = $\frac{WL^2}{96}$ W = lb. per foot.

Occurs at middle of span.

Use Case 1 and 2 for 4 wheel cranes; case 3 and 4 for 8 and 16 wheel cranes or where 2 cranes of equal wheel loads are on the same runway; case 5 and 6 for cranes of unequal wheel loads on the same runway; and case 7 for dead load moment produced by runway beam and rail.

The vertical moment divided by the section modulus of the selected beam plus the lateral stresses should not exceed the allowable stress prescribed by local building codes or the recommendations found in the current edition of "Manual of Steel Construction" by the American Institute of Steel Construction, A.I.S.C.

The maximum shear due to moving concentrated loads will occur at one support when one of the loads is at that support and will equal the total reaction at that support.

The usual structural members for runway beams are: standard I-beams, wide flange beams, capped beams, or built-up sections of single web or box girder design.

If the runway conductors are to be attached to the runway beam, it is most economical to have the beams properly punched during shop fabrication to receive the conductor support brackets.

Wheel stops shown on page 63 may be used as runway stops. It is recommended that the stops be fastened directly to the beam as in Figure 19 and 21, rather than bolted through the rail web as trolley wheel stops. It is also good practice not to engage the crane wheel as the impact is then transmitted through the wheel bearings and axles. Engaging the structural truck, Figure 185, is preferred.

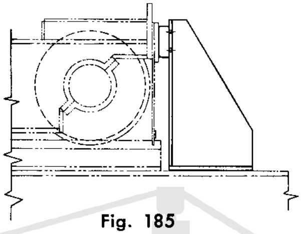


Fig. 185

For bridge speeds in excess of 250 FPM, the crane should be provided with bumpers capable of stopping the crane (not including the rated load) when travelling in either direction at 50% of the rated full load speed, and at a rate of deceleration not to exceed 16 ft. per sec. per sec. Such bumpers shall have sufficient energy absorbing capacity to stop the crane when travelling at a speed of at least 50% of the full load rated speed.

The design of the energy absorbing feature shall be based on the following formula:

$$F = \frac{WV^2}{2GS}$$

W = weight of crane in pounds
V = velocity in feet per second
G = 32.16
S = Bumper plunger travel in ft.

Divide above result by 2 to obtain the value required for each bumper.

Impact on end stop = $E - E_1$.

$$E = \frac{WV^2}{2G}$$

E = Kinetic energy

$$E_1 = PS$$

P = Average spring pressure

Add for 10 pounds per square foot wind on projected area of crane for out-door cranes.

Energy-absorbing feature may be mechanical, such as springs, rubber, polyurethane, etc., hydraulic or pneumatic. For hydraulic units it is recommended that they be designed for the full extent of the energy to be absorbed.

BEAM SUPPORTS: Indoor crane runways are usually supported on building columns or brackets attached to these columns.

A simple bracket, Figure 186, may be used for Class A and B cranes of light capacities. Figure 187 is used for Classes A, B, C and D of light and medium capacities. Cranes in heavy-duty service, Classes

D, E and F, and heavy capacities in Class A and C, a design incorporating the direct use of the building column, Figure 188 and 189, is used. The brackets may be of welded, rivetted, or bolted design.

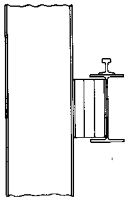


Fig. 186

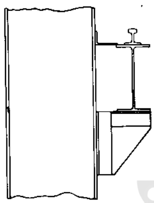


Fig. 187

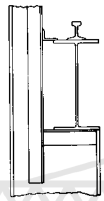


Fig. 188

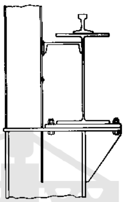


Fig. 189

COLUMNS: Columns having brackets on the side, Figure 186 and 187, have an eccentric load which causes bending stresses in addition to the compressive stress produced by the direct load. The following will provide a check on the selection of a column section:

P = Concentric (direct) load in pounds.
P_1 = Eccentric (bracket) load.
Y = Distance center of column to center of runway beam.
M = Bending moment due to eccentric load = P_1Y.
S = Section Modulus in corresponding direction of bending.
A = Area of column section.

Combined stress (f) due to compression and bending $= \frac{P + P_1}{A} + \frac{M}{S}$

In determining the allowable stress per square inch the lateral strength at right angles to the direction of bending must be considered. l = length of column in inches; r = least radius of gyration as found in structural handbooks; allowable stress when l/r is not greater than

120: $f = 17{,}000 - 0.485 \frac{l^2}{r^2}$; allowable stress when l/r exceeds 120:

$$f = \frac{18000}{\text{one} + \frac{l^2}{18000r^2}} \left(1.6 - \frac{l/r}{200}\right)$$

For tables of values consult the AISC Manual of Steel Construction.

Consult the latest edition of the American Institute of Steel Construction "Manual of Steel Construction" for variations of the above formulae and tables of values to take advantage of the higher yield strength materials offered by the manufacturers.

Outdoor crane runways are supported on "A" frames, Figure 190 or columns with overhead truss connections, Figure 191. In Figure 190 the column is designed as above; the secondary member and bracing permit l/r ratios up to 200. For stability B should equal A/4.

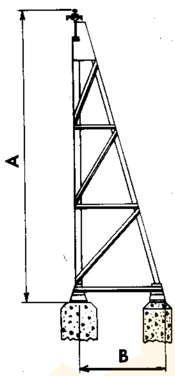


Fig. 190

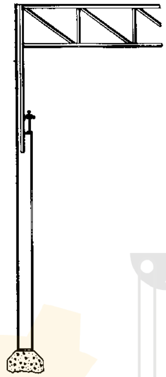


Fig. 191

In determining the height of runway another point, besides lift, to be considered is that railroads require a minimum clearance of 22'6" between their tracks and any overhead obstruction. Special permission must be obtained if it is impossible to provide this clearance.

FOUNDATIONS: The base of the column is mounted on a base plate which is of sufficient area to provide a uniform bearing pressure (usually 600 to 800 PSI) on a concrete foundation. The column load is assumed to be uniformly distributed within a rectangle whose dimensions are .95 x depth of beam and .80 x width of flange. Maximum bending stress in base plate should not exceed 20,000 PSI.

The area and depth of the concrete foundation is dependent upon local soil conditions and should be checked with the proper authorities in your local area. A conservative average soil bearing pressure of 2 tons per square foot may be considered. However, bearing pressures must be kept within safe limits to insure the constant level and alignment of the runway rails.

GENERAL: A well-built runway and adequate column foundations will yield dividends in maintenance and life of the crane. Acceptable tolerance for spans ± 1/4" up to 100'0"; ± 5/16" over 100'0". All tolerance is provided in width of wheel tread as most bearing assemblies make no provision for wheel float. Where the span cannot be kept within the above tolerances, provision for wheel float should be made in the bearing assembly. Runways should be installed and maintained level with each other and without slope throughout the entire length. Small misalignments are generally overcome by the tapered tread wheels. When misalignment becomes excessive, causing wheels to bind, flanges of wheels are often broken, wheel bearings are overloaded, and the bridge motor requires excessive current to move the bridge over areas in which the wheels and rails produce binding.

RUNWAY CONDUCTORS

Runway conductors are divided into four groups: (1) bare copper wires, (2) rigid shapes of steel, aluminum or copper, (3) enclosed contact type, and (4) insulated cables.

BARE WIRES: Bare hard drawn copper wires of the rigid support, Figure 192, type is the most popular system; followed by the spool support (loose wire), Figure 193 design. Both systems are supplied with end anchors, Figure 194; intermediate supports spaced on 20 foot centers; and vertical spacing of wires at 8 to 12 inches. Collectors for both these systems are found on page 74.

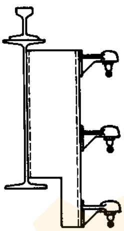


Fig. 192

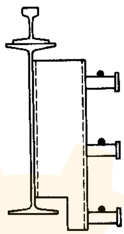


Fig. 193

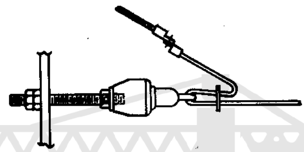


Fig. 194

The size of wires is determined by the sum of the ampere ratings of the largest plus ½ next larger motors, the length of the runway, the number of cranes on the runway, and the availability and location of power feed stations. For the runway conductors, a maximum voltage drop of 3% is considered acceptable. This should be figured for the average crane operation expected when the runway has its full complement of cranes. The sum of amperes of all motors that may operate at the same time must be considered. A center feed or 2 supply taps, one at 1/6 of the total length from each end, will hold voltage drop to a minimum. Copper wire tables give the ohms per foot rating; the voltage drop may be found by the following formula:

Ohms per unit distance x number of units x amperes x two for proper location of power feeds. It is important that the conductor size be ample to transmit full voltage because the maximum torque is proportional to the square of the voltage.

Table 43 — DC Resistance at 25° C. in Ohms Per 1000 Feet for Hard Drawn Bare Copper Wire

Wire Size	Ohms	Wire Size	Ohms	Wire Size	Ohms
4	.2584	1/0	.1011	300,000 CM	.0312
3	.2049	2/0	.0802	400,000 CM	.0260
2	.1625	3/0	.0636	500,000 CM	.0205
1	.1289	4/0	.0505		

$$\text{Formula for ohms, Table 43} = \frac{VD \times 500}{L \times A}$$

For AC,VD = 3.3 for 110 volts; 6.6 for 220; 13.2 for 440.

For DC,VD = 3.3 for 110 volts; 7.0 for 230; 16 for 550.

L = length in feet from feed-in to crane at extreme of runway,

A = Amperes, see Table 16 of H.P. ratings.

For mechanical strength and wear, No. 2 conductors are minimum size for runway conductors. With one crane on a runway, add one size more than that required by load; with 2 or more cranes on the same runway, add 2 sizes more than that required by load to allow for wear.

RIGID SHAPES OF STEEL, ALUMINUM OR COPPER: Angles or tees of the three materials mentioned are supported in different ways depending upon where the contact surface is to be located. The following mountings are illustrated: Angles or tees — underwipe, Figure 195; sidewipe, Figure 196; topwipe, Figure 197 and inverted angle underwipe, Figure 198. Bars — topwipe, Figure 199. The conductors should be supported at intervals not to exceed 80 times the vertical dimension of the conductor, but in no case greater than 15 feet; and spaced apart sufficiently to give a clear electrical separation of not less than 1 inch between any contact point of conductor, collector or supports.

Rails are also used as conductors and are so mounted that the contact surface may be the head or base of the rail and arranged for topwipe or underwipe collectors.

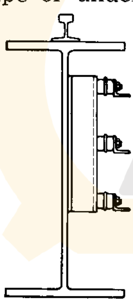


Fig. 195

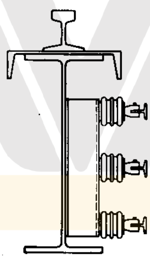


Fig. 196

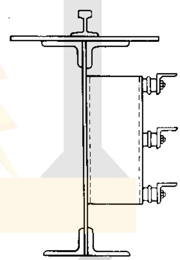


Fig. 197

The size of conductors is usually determined by mechanical, structural, and wear factors, but it is well to check them for current-carrying capacity. For low-carbon steel the net cross-section area must be from 6½ to 8 times the area of the copper wire and for high carbon steel must be 11 times the area of copper. At no time shall the electrical capacity exceed 300 amperes per square inch. Aluminum should be 1.2 times the area of copper.

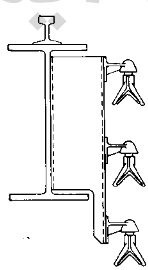


Fig. 198

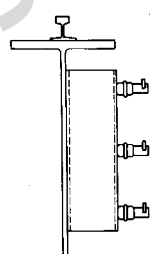


Fig. 199

Rigid conductors of the above types are used in severe operating conditions where heavy currents and long runways are found. Mechanical wear and replacement are negligible.

Other types of rigid-shape conductors include: Insul-8 Bare Bar; Delta Star Keystone integrated Aluminum Conductor and the C-Bar system in bronze, aluminum or copper; and Ringsdorf Copperhead rail conductor system.

ENCLOSED CONTACT TYPE: Where safety demands protection for personnel from exposed conductors, some of the available systems of this type are the following: Trol-E-Duct, Figure 200; Feedrail, Figure 201; Trumbull, Figure 202; Insul-8-Bar, Figure 203 for under contact and Figure 204 for side contact; Insul-8 Hevi-Bar, Figure 205 for 500 and 1000 ampere systems; Delta-Star Lec-Trol Feed, Figure 206; U. S. Safety trolley system, Saf-T-Lek, Figure 207; Duct-O-Bar, Figure 208; Duct-O-Wire, Figure 209.

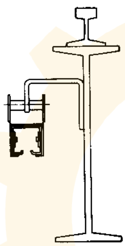


Fig. 200

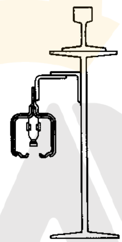


Fig. 201

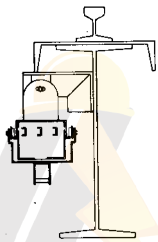


Fig. 202

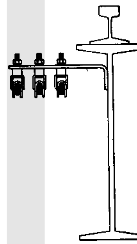


Fig. 203

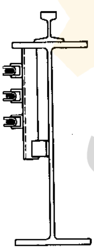


Fig. 204

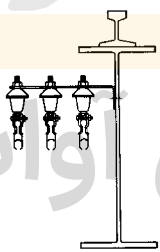


Fig. 205

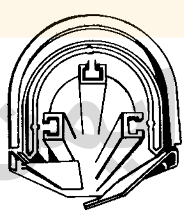


Fig. 206

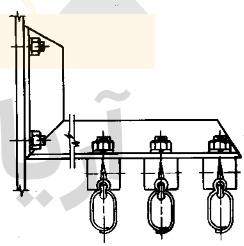


Fig. 207

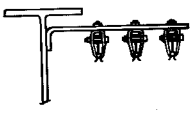


Fig. 208

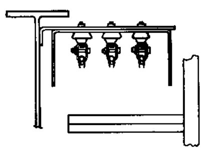


Fig. 209

The Insul-8-Bar enclosed conductors ,available in a wide range of ampere capacities, provide a safe, low cost, flexible system for cranes or monorails. In the horizontal arrangement, Figure 203, they may be as close as 1⅛″ apart; thus saving much space in a multiple conductor system.

INSULATED CABLES (non-contact): To avoid open conductors of any type, the use of multi-conductor cables for runway conductors is coming into use. This system is especially adapted to explosion-proof installations or in those areas where sparks may ignite flammable material or in adverse atmospheric conditions.

This system is also used extensively on out-door gantry cranes in the electric utility field. The cable take-up is accomplished with motor- or spring-powered cable reels, Figure 210; or cable supports such as Gleason Powertrak or Ringsdorf Cable Veyor.

Before specifying a conductor system, the local and State codes should be checked for specific requirements.

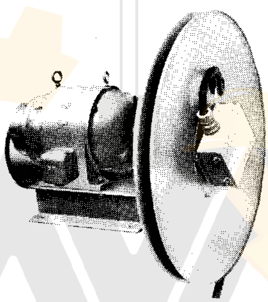


Fig. 210

SECTION XV

ERECTION, OPERATION & MAINTENANCE

Cranes purchased from a reliable crane builder are assembled at the factory, properly wired, tested without load, and taken apart only as required for shipment. Field assembly is made easy by thorough match-marking of each disassembled part and the whole crane is marked to identify the cab position, and the correct position of the trolley on the bridge.

As the crane builder is not an erection contractor, arrangements for unloading and erecting the crane on the runway should be made well in advance. The steel contractor on new projects usually does this work. A local rigging contractor or steel erector should be contacted for cranes to be installed in existing buildings. It is recommended that this work be done under the supervision of the crane builder's superintendent of erection. The contractor will place the crane on the runway and make all connections. The superintendent of erection will check all work and place the crane in service.

A railroad track extending into the crane bay is of the greatest convenience, as parts may be hoisted directly from the cars to the runway and avoid the lifting and transporting necessary where tracks are remotely located.

Light cranes may be lifted directly from the roof trusses, either from the top chord of a single truss or by placing a beam between two trusses and suspending hoist rigging from the center. Attaching rigging to the bottom chord results in loss of lifting distance so that crane cannot be raised above the runway rail.

Heavier cranes may require the use of two trusses or sufficient strength may be designed into one truss for the purpose of crane erection and later handling of the heavy components. If trusses are not available, the erector must have gin-poles and tackle of sufficient strength to safely handle the heaviest piece usually the complete trolley or the drive girder with its machinery, footwalk, and if possible, the two bridge trucks.

If the trucks cannot be attached to the drive girder, they are placed on the runways first. The drive girder with its machinery and footwalk is raised and attached to the truck ends. Next the idler girder is placed on the trucks and all bolts are put in and tightened. No drift pins should be used as holes are reamed in place before the crane is dismantled for shipment.

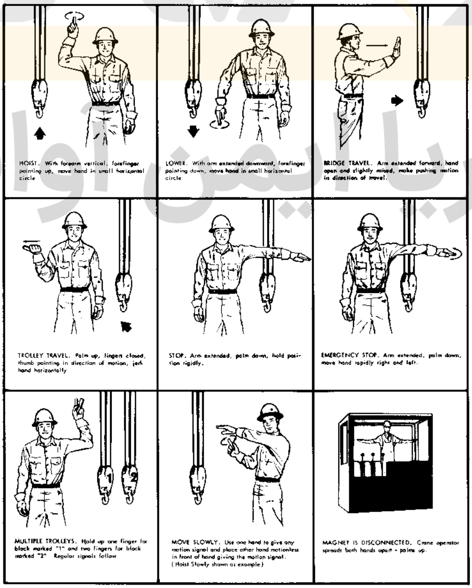
The bridge is now moved out of the way and the trolley hoisted above the level of the bridge rails. The bridge is moved back under the trolley and the trolley is then lowered into position. Collector shoes are attached and all electrical connections made as instructed.

The cab is erected by rigging from roof truss or pole, using care that it will be picked up as level as possible. Remaining parts such as, guards, switches, and accessories are attached and the crane thoroughly lubricated and gear cases filled before the motors are tested for direction. It may be necessary to reverse the leads so that controls and limit switches will function as intended.

Crane hoisting rope is next unrolled to its full length on the floor and the block reeved up. If block does not hang square, detach one end of the rope from the drum and twist until the trouble is corrected. Hoisting rope should be lubricated before use.

As a crane represents a sizeable investment, extreme care should be taken to see that it is started under ideal conditions and then maintained by the best standards of maintenance for heavy machinery. Thorough attention to the following points is recommended: (1) Tighten all bolts and see that they are provided with lock washers or locktype nuts; (2) Remove all loose parts and tools from trolley, girders or footwalk; (3) Remove all spilled oil or grease for safety; (4) Lubricate as instructed; (5) Grease hoisting rope; (6) Check rotation of each motor to correspond with control handle movement; (7) Adjust limit switches; (8) Check the action of each brake. Operate the crane slowly for a few hours, then inspect all keys, bolts, brakes, etc. Repeat this inspection within a few days after the crane is in regular operation, and then inspect every week.

To encourage the use of uniform signals from floor to crane operator, we are showing the following chart:



The safe operation of a crane is the responsibility of the crane operator. His job is important because he may handle materials and finished parts many times in a production process. He is responsible for the safety of his fellow employees and the reliable service which his piece of machinery is capable of performing. The crane operator must know his crane thoroughly, make regular inspection of all parts, and operate safely at all times. It is not the purpose of this book to be a crane operation manual so reference is made to a booklet, "Rules for the Safe Operation of Overhead Traveling Cranes", published by the Whiting Corporation and available upon request. Reference is also made to the United States of America Standards Institute Safety Code B30.2 Chapter 2 and 3.

A good crane operator can do much to reduce maintenance and prolong the life of the crane by careful manipulation of the controls, allowing the motors to accelerate gradually to avoid heavy impacts, high current requirements, and swinging loads; and then coasting to stops rather than making sudden stops by plugging the motor or making vicious applications of the brakes resulting in skidding of the driving wheels which in turn produce flat-spots on the wheels. Flat wheels produce vibrations and impacts which reduce crane life and add to operator fatigue.

Depending upon the number of cranes in a plant, the inspection, lubrication and maintenance may be made the responsibility of the crane operator or the plant maintenance department. In either case, the operator must report on the condition of his crane at regular intervals and obtain immediate action on any condition that is not safe.

The intervals for inspection depend upon the type of crane and how much it is in use. The crane life may be prolonged and the maintenance costs kept at a minimum by following a few simple practices.

Many mechanical failures can be traced to lack of lubrication. Therefore, it is important that a lubrication schedule be established and that all points requiring attention be serviced. These to include: grease for all wheel, cross-shaft, sheave, drum, brake, motor, controller, and accessory bearings; oil for gear cases, reducers, couplings and pins; and grease for open-type gearing and hoisting ropes, as recommended by the crane manufacturer.

For cranes in severe operation a centralized lubrication system in which the lubricant is piped to each point and pumped from a central point to each bearing is recommended. This system reduces man-hours required to lubricate a crane and makes the job safer for the maintenance man by reducing the necessity of climbing on the crane.

The crane should be thoroughly inspected at regular intervals. To aid in this schedule, most crane builders provide a check sheet, with the crane, or available upon request, that lists all the points to be inspected at definite suggested intervals. All irregularities are noted and minor adjustments are made. To get the full benefit of such inspections, a follow-up must be made to see that recommendations of the report are followed, adjustments made, and the defective parts ordered and replaced as soon as possible. This system will reduce down-time and eliminate costly failures.

Crane life is decreased and maintenance costs increased by the handling of loads above the rated capacity of the crane. The usual test loads of 125% capacity for a new crane based on a factor of safety of 5 still allows a factor of 4 with only a maximum of 25% overload on the motors. At the time of this test the crane is in first-class condition and all components are in nearly perfect adjustment. After a period of use, adjustments, such as brakes, may no longer be good and any overload may create an unusual operating condition that may weaken parts of the crane. It is the recommendation of the crane builders that the crane be of sufficient rated capacity to handle the heaviest known load and therefore, not subject the crane to loads greater than the rated capacity which might jeopardize the safety of plant employees.

United States of America Standards Institute Safety Code B30.2 covering construction, installation, testing, inspection, maintenance and operation of Overhead and Gantry cranes stresses the fact that the rated load shall be the maximum load handled by the crane except for the initial test. It is recommended that all supervisory and operating personnel be acquainted with this Safety Code as the entire code or separate sections of it may be enacted into laws and regulations by the separate States.

SECTION XVI — SAFETY FEATURES

Many of the so-called "Industrial States" have adopted safety codes covering crane design and operation. The enforcement of these codes is in the hands of the State Industrial Commission. Such codes that deal with factors of safety and safety devices to protect workmen should be encouraged, whereas those that try to dictate detail design should be discouraged because they soon become out-of-date and only add to the initial cost of a crane. Crane builders make a study of each code, incorporate the good features in their standard cranes and add the extra features to those cranes which go into states that have special requirements.

For Class F cranes, The Association of Iron and Steel Engineers have incorporated many desirable features in the latest revision of their AISE Specification No. 6.

All safety features assure owner benefits. They protect workmen from accidents, give men greater confidence while they go about their duties, and lower insurance rates due to the reduction in accidents. Crane safety has been discussed in Section IX. For the safety of all plant personnel, the following features should be incorporated in a "safe" crane:

1. All gearing enclosed.
2. No overhanging gears or pinions that may work loose.
3. Rail sweeps at all bridge and trolley wheels.
4. Steel walk with safety treads, toe-boards and hand-rail on drive side, and closed from hand-rail to girder.
5. Guards over cross-shaft couplings.
6. Ladder from cab floor to foot-walk.
7. Bridge brake controlled from cab.
8. Lubrication points not readily accessible should be piped to a convenient access point.
9. Two brakes on the hoist — one control braking means (mechanical or electrical) and one holding (fail-safe) brake.
10. Limit switch of the automatic reset type, to prevent overtravel of the hook.
11. Main line switch enclosed in steel safety cabinet, interlocked so that main switch is "out" before cabinet can be opened.
12. All wiring properly insulated and run in conduit or ducts.
13. Enclosed or guarded load blocks.
14. Safety latches for hooks of yard and foundry cranes.
15. A gong or siren mounted on cab and operated by foot switch or lever.
16. Enclosed cab glazed with safety glass.
17. Out-door cranes equipped with parking brake which locks wheels when not in use.
18. Cab arranged to give operator clear vision of the hook in all positions.
19. All electrical equipment suitably guarded for protection against accidental contact.
20. Hook and block painted for high visibility.

SECTION XVII — MODERNIZING OLD CRANES

With reasonable maintenance a crane has a long life and is usually replaced only if it is the "bottle-neck" of a faster production schedule. A crane may be modernized in many ways that would prolong its usefulness depending upon the additional investment the user is willing to make. If the cost to completely modernize a crane exceeds 40% of its replacement cost, it would be economically sound to put a new modern crane in its place.

A major improvement in crane operation can be made by replacing the trolley of the present crane with one of equal capacity, higher speeds, more efficient gear cases, anti-friction bearings and more safety features. This change would result in stepped-up operations, lower power consumption, and reduced maintenance.

If many light loads are handled, operating expenses could be reduced by the addition of a high speed, light capacity auxiliary hoist. This may be a commercial unit attached to the trolley frame or a custom-built unit on a trailer frame coupled to the existing trolley.

A heavy capacity crane may be handling only light loads in which case it would be only a minor change to reduce the capacity and increase the speeds by a change of the gearing, or in the hoist motion, by a change in the rope reeving from 12 parts to 8 parts or from 8 parts to 4 parts thereby increasing the speed 50% or 100% without a change in the electrical equipment. A speed-up may also be obtained by replacing the original motor with a new one of larger horsepower at a higher speed.

The older cranes were usually over-designed and may be rerated by carefully checking each component by the formulae given in Section IX. A few low-cost reinforcements may materially increase the capacity of the crane. The principal points to be figured are the hook, block, ropes, sheaves, pins, wheel axles and bearings, gearing, motors and trucks.

Certain components of old cranes may be causing much maintenance and it may be more economical to replace these components with units of advanced design rather than to repair the obsolete units. The lever-operated bridge brake may be replaced by the smooth, positive-acting hydraulic brake. Dangerous and obsolete hoist brakes can be replaced with modern mechanical, electrical or magnetic brakes. Heat-treated gearing may eliminate troublesome replacement of gearing. The installation of positive-acting modern limit switches can prevent accidents caused by over-hoisting. New approved collectors will reduce pick-up maintenance and increase life of conductor systems. The addition of spring bumpers on the trolley may reduce shock and impact to such an extent that the life of the crane will be lengthened.

The keeping of a maintenance record will reveal the most troublesome items. These items should be replaced with up-to-date units to reduce down-time and assure dependable crane performance.

WHITING PRODUCTS: MATERIAL HANDLING EQUIPMENT

CRANES

Overhead	Magnet	Jib
Gantry	Charging	Pillar
Bucket	Circular	

Regardless of the application, you will find a Whiting crane that will speed up production and reduce handling costs with lowest cost crane service.

TRAMBEAM

Turn "overhead" into profit with increased plant capacity by installing Trambeam monorail, cranes or stackers that permit maximum use of all available space for transport or storage.

PRESSUREGRIP

Pressuregrip vacuum lifting attachments and systems for handling flat or contoured shapes provide positive gripping action, absolute safety and economy in handling non-porous materials of all kinds.

TRACKMOBILE

The Trackmobile is a gasoline- or diesel-powered machine, priced at a fraction of the cost of conventional-type plant locomotives, that operates on both road or track. It spots, switches and hauls railway cars on tracks and industrial trucks on roads and in plants with amazing versatility—speeds production, saves time and cuts costs. A full range of capacities for all conditions of operation are available.

FOUNDRY EQUIPMENT

Cupolas	Electric Arc Furnaces	Annealing Ovens
Hot Blast Equipment	Ladles	Annealing Cars
Duplexing Systems	Tumbling Mills	Pulverizers
Air Furnaces	Induction Furnaces	Turntables
Charging Equipment		Spark Suppressors

Since 1884, Whiting has been a leading producer of foundry equipment of all types.

TRANSPORTATION EQUIPMENT

Drop Tables	Washers	Car Pullers
Portable Jacks	Locomotive Sanding Facilities	Interior Bus Vacuum Systems
Train Washers	Cross-over Bridges	Rip Jacks (pit installed, Mechanical & Hydraulic)
Bus Washers	Transfer Tables	Wheel Grinders
Interior Boxcar Washers	Railcar Progression Systems	
Interior Hopper Car		

Specialized engineered systems and equipment for maintenance and movement of rolling stock for all industries.

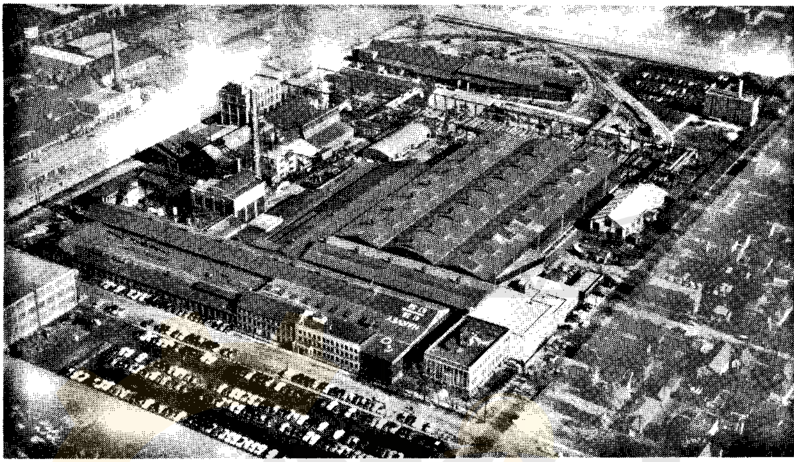
SWENSON EQUIPMENT

Evaporators	Crystallizers	Dryers:
Condensers	Centrifuges	Spray
Coolers	Filters	Rotary
Heat Exchangers	Process Equipment	Fluidized Bed

Swenson, a division of Whiting Corporation, has been a leading manufacturer of process equipment since 1889. Their research facilities play an important role in the ultimate design of many installations. Swenson research centers in Harvey, Illinois, are staffed and equipped to conduct test runs with many types of materials. They welcome the opportunity to confer on your needs, test run your materials and submit samples for market analysis.

SPECIAL EQUIPMENT

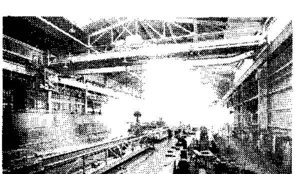
There is no substitute for Whiting Experience in building special machinery for any problem you may have.



MAIN OFFICE AND PLANT, HARVEY, ILLINOIS

ENGINEERING

MACHINE SHOP



ASSEMBLY

VAST ENGINEERING EXPERIENCE

For almost 80 years Whiting engineering has developed new and better equipment and machinery for all industry.

Whiting engineering has not only made outstanding products possible, but it has helped companies apply these products in the most efficient manner. Whiting engineers work closely with consulting and company engineers. Together they work as a team . . . in analysis, layout, design, testing and recommendation of products to be used. Together they solve the problem and obtain the desired results in increased production and lower costs.

COMPLETE MANUFACTURING FACILITIES

Whiting products are engineered and built in plants located in Harvey, Illinois; Attala, Alabama, and Welland, Ontario, Canada. The main plant and general offices are in Harvey (a suburb of Chicago). Here are 30 buildings, occupying over 20 acres . . . complete with research and development laboratories, with the Company's own forge shop, and with modern facilities for production manufacture.

WHITING DISTRICT OFFICES

BIRMINGHAM ALABAMA 35223 — 16 Office Park Circle

BOSTON, MASSACHUSETTS
81 Arch Street, Needham, Massachusetts 02192

CHARLOTTE, NORTH CAROLINA 28204 — 1416 East Morehead St., Kingsmore Bldg.

CHICAGO, ILLINOIS
157th & Lathrop Avenue, Harvey, Illinois 60426

CINCINNATI, OHIO 45227 — 5710 Wooster Pike (Rm. 217)

CLEVELAND, OHIO
356 E. 270th Street, Euclid, Ohio 44132

DETROIT, MICHIGAN
28840 Southfield Road, Lathrop Village, Michigan 48075

HOUSTON, TEXAS
P. O. Box 98, Bellaire, Texas 77401

INTERNATIONAL SALES
157th & Lathrop Avenue, Harvey, Illinois 60426

KANSAS CITY, KANSAS
10125 Maple Drive, Shawnee Mission, Kansas 66207

LOS ANGELES, CALIFORNIA
450 Bel Vue Lane, Balboa, California 92661

NEW YORK, NEW YORK
171 E. Ridgewood Avenue, Ridgewood, New Jersey 07450

PHILADELPHIA, PENNSYLVANIA
No. 9 Rittenhouse Place, Ardmore, Pennsylvania 19003

PITTSBURGH, PENNSYLVANIA 15222 — 1109 Empire Buliding.

ST. LOUIS, MISSOURI 63105 — 8029 Rosiline Drive

SEATTLE, WASHINGTON
17115 N. E. 5th Place, Bellevue, Washington 98004

WHITING SALES AGENTS

DENVER, COLORADO — Peterson Company, 4949 Colorado Blvd.
— Kramer Industrial Supply, Inc., 2190 East 40th Avenue

OMAHA, NEBRASKA 68102 — Cardinal Supply & Mfg. Company, 915 North 19th Street

SALT LAKE CITY, UTAH 84101 — James J. Burke Company, 422 West 9th South

AFFILIATES

Whiting Equipment Ltd., 350 Alexander Street, Welland, Ontario
Societe Francaise Whiting Fermont, 27 Rue Laffitte, Paris 9°, France
Equipos Petroleros Nacionales, S.A., Av. Newton 186-Desp.502, Mexico 5, D.F.

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