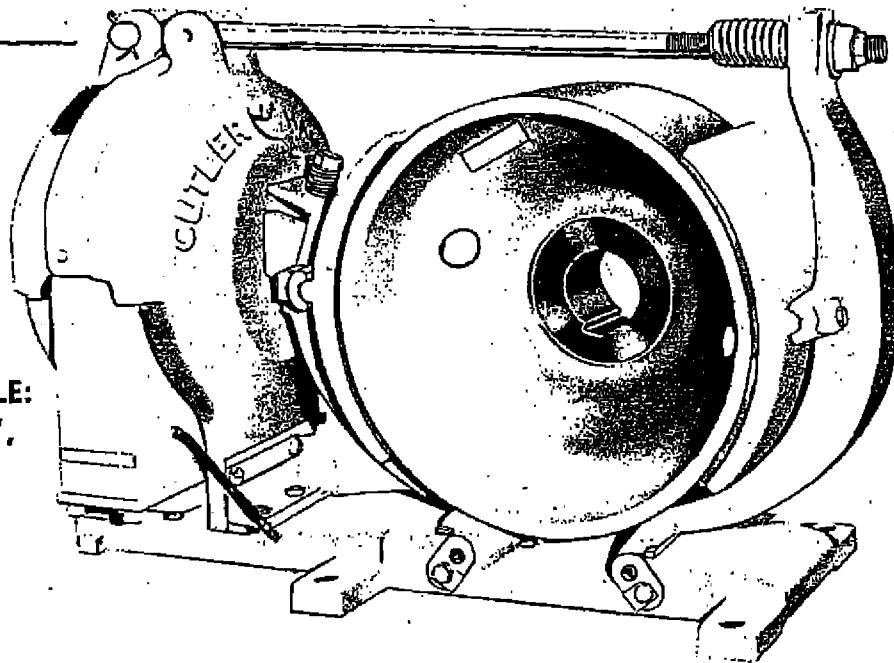


505

electro mechanical

brakes torque ranges available from 65 to 9000 lb. ft.



**SEVEN WHEEL
SIZES AVAILABLE:**
8", 10", 13", 16",
19", 23" & 30"

Cutler-Hammer electro mechanical, magnetic shoe brakes conform to NEMA-AISE standards and are designed for application on movable bridges, cranes, rolling mill drives, hoists, etc.

Wear and freezing are virtually non-existent on C-H brakes due to their design which eliminates all pivot pins but one (pull rod to armature). This single pin type pivot is maintained because it is doubly functional in that it also allows the pull rod to be easily swung out of the way if straight-up removal of the wheel is necessary.

The structural members of the 8" thru 23" brakes are made of ductile iron and their bases and armatures are made of cast steel. The 30" differs only in the base which is a steel weldment with laminated steel armatures.

Three enclosures are available to protect the brake from severe environments: (1) Partial Wheel Cover — which goes over the top of the wheel and extends over the shoes; (2) NEMA 3 Lift Off — which covers everything but the coil and outer armature; and (3) NEMA 4-5 — which is watertight and dusttight.

optional manual release lever

Quick acting, self resetting, this device permits simple, controlled torque release in the event of power failure. Operator merely raises the lever which cams the armatures together thus allowing controlled release of the brake holding force. There's no change in brake adjustment, no delay in resetting, and no downtime for re-adjustment. Available for 8" thru 23" brake sizes.

CH-000478

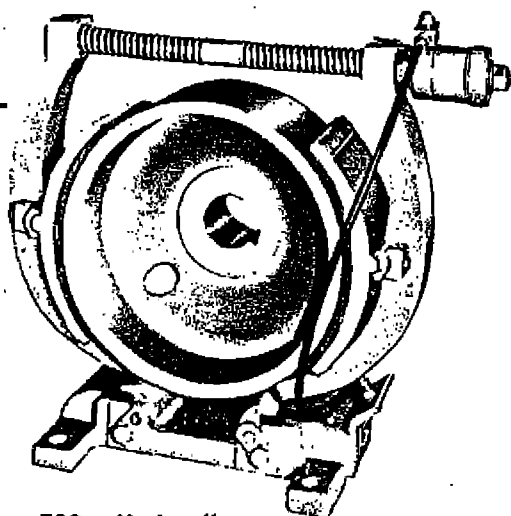
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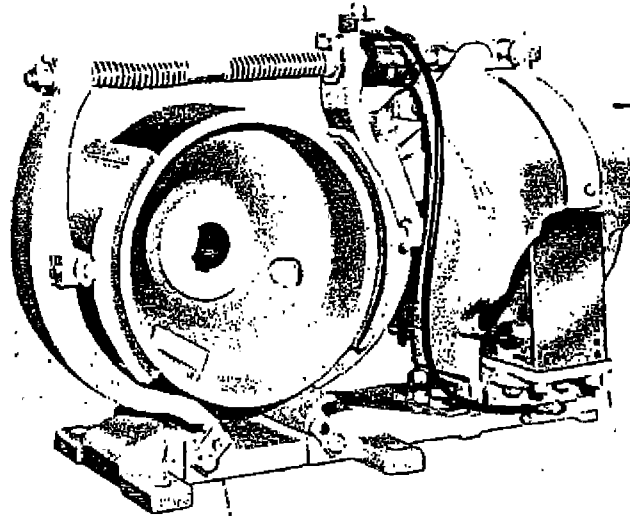
506 & 509

hydraulic brakes

variable braking provides the ultimate in stopping control



509 — Hydraulic



506 — Electro hydraulic

FIVE WHEEL SIZES AVAILABLE: 8", 10", 13", 16" & 19"

Hydraulic brakes give operators complete control of speed at which load is moving — thus increasing efficiency and improving safety. With the Type 506 Electro Hydraulic Brake the electrical system holds the brake released, and the pedal-operated hydraulic system enables controlled variable pressure braking for slowing and stopping functions. Type 509 is hydraulic only, depending on spring tension to hold the brake released. The hydraulic systems in both models operate the same as the braking system of an automobile — the more pressure applied to the pedal, the greater the braking torque. Both systems operate over the full range of speeds.

C-H hydraulic brakes comply with NEMA-AISE stan-

dards. Eight out of ten parts are interchangeable with mechanical brakes to considerably reduce parts inventory requirements for users of both mechanical and hydraulic systems.

optional power assist accessory

This new device enables the use of hydraulic braking power on as many as four brakes simultaneously from a single control station. What's more, control may come from any remote source such as a footswitch, pendant station or radio control transmitter. The power assist greatly increases braking efficiency on many applications and reduces operator fatigue.

CH-000479

CUTLER-HAMMER

INDUSTRIAL SYSTEMS DIVISION, Milwaukee, Wis. 53201





9-15-66

HEAVY DUTY MAGNETIC BRAKES

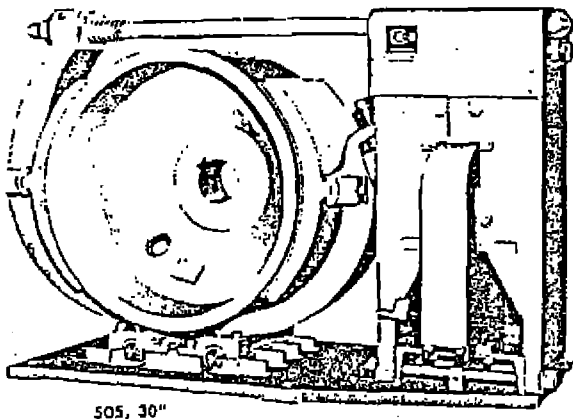
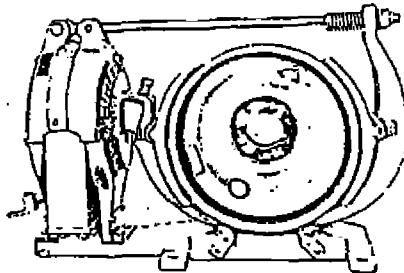
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505 Electro-Mechanical

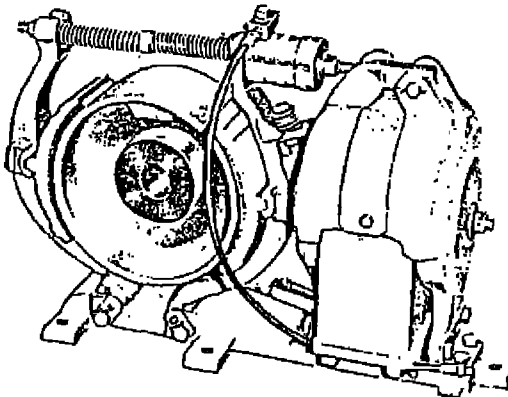
506 Electro-Hydraulic

DESIGN CHARACTERISTICS

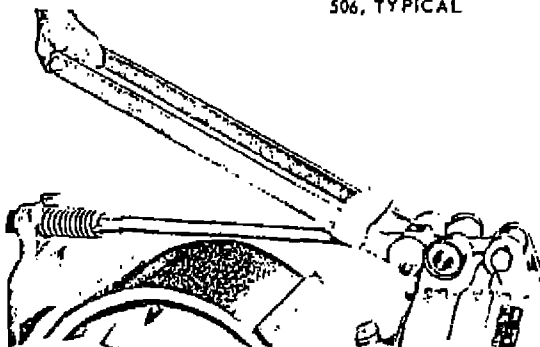
- GENERAL - D-c operated shoe brakes. Short-stroke magnet and armature structure. Electrically released and spring set. 506 has added hydraulic system independent of spring-set mechanisms.
- STANDARDS - AISE and NEMA ratings and dimensions. NEMA 1 mounting (base on horizontal surface).
- TORQUE RATINGS - 65 lb-ft through 9,000 lb-ft. Equal stopping and holding when spring-set. Equal torque for either direction of wheel rotation. Hydraulically applied torque infinitely variable.
- COILS - Series $\frac{1}{2}$ or 1 hour. Shunt Intermittent of continuous. Class B insulated. NEMA 3 enclosed. Leads (about 4" long) supplied with copper lugs. Reversible so that leads point toward or away from wheel. Separately supplied resistor for shunt brakes.
- LININGS - Asbestos with constant coefficient of friction under operating conditions. Pinned to brake shoes.
- WHEELS - Special cast ductile iron. Standard castings for most requirements. Tapered bore (with keyway), tolerance .005", tapers of 1.250" or 1.219" per foot on diameter. Straight bore (with keyway and setscrew), tolerance .001". Physical and metallurgical properties not affected by excessive temperatures.
- CONSTRUCTION - Structural members made of ductile iron, except 30" base which is plate steel. Laminated armatures in 30", cast steel armatures in 8" through 23".
- INSTALLATION - Magnet end can be to left or right. Adjustments and settings require only 1 crescent wrench. All adjustment points are readily accessible.



505, 30"



506, TYPICAL



505, OPTIONAL MANUAL RELEASE LEVER

OPTIONAL FEATURES

- COIL CIRCUIT FOR SHUNT BRAKES - Protective panel to obtain intermittent duty ratings on continuous duty applications. A-c rectifier panel which has coil protective circuit included for 8" through 23" brakes. A-c rectifier panel for 30" brakes but without coil protective feature. Increased or decreased release and/or set time, special voltages, etc.
- ENCLOSURE - Wheel protective cover on pull rod of 505 only. NEMA 3 weather resistant. NEMA 4-5 watertight and dusttight.
- WHEEL - Special offsets, bores, castings, etc. Safety flange, $\frac{1}{2}$ " x $\frac{1}{4}$ ", on motor side, shoes retain wheel if wheel loosens or if motor shaft breaks.
- DUPLEX INSTALLATION, 506 ONLY - 1 brake operated from 2 master stations. 2 brakes operated from 1 or 2 master stations.
- MOUNTING - NEMA 2 mounting (base on vertical surface with magnet structure up).
- MANUAL OPERATION, 505 8" THROUGH 23" ONLY - Manual self-returning variable torque lever. Screw type non self-returning release.

CH-000480

HEAVY DUTY MAGNETIC BRAKES

9/15/66



505 Electro-Mechanical 506 Electro-Hydraulic

DESCRIPTION

-H 505 and 506 brakes are electro-mechanical D-c operated shoe brakes. They are electrically released and spring set and are therefore fail-safe under power failure. Torque due to spring-setting is fixed as adjusted. 506 brakes have added hydraulic linkages which permit variable torque independent of spring-set torque.

Both brakes are identical except for the pull rod and the inner shoe lever. 505 brakes shipped since January, 1962, can readily be converted to 506 brakes.

Detailed descriptions of standard and optional features of -H 505 and 506 brakes start on this page immediately after "Selection".

OPERATION

When the coil is energized, the armatures move together to compress the torque spring and move the shoes away from the wheel to release the brake. De-energizing the coil allows the torque spring to separate the armatures and press the shoes against the wheel to set the brake. Torque is constant during stopping and holding.

506 brakes operate exactly as 505 brakes with the exception that the operator can impose hydraulically actuated torque at any time. In normal (service) operation, the brake is electrically released constantly, and braking is hydraulic. The brake is spring-set only to hold (park) the system.

If a hydraulic system is used, options are available to operate 1 or 2 brakes from 2 masters or from 1 master.

SELECTION

For most applications, the brake torque must simply equal the full load motor torque as reflected to the wheel. The formula for this figure is:

$$T = \frac{5250 \times HP}{RPM_{wheel}}$$

With the torque requirement known, and the type and duty cycle established, the Selection Table on page 4 will indicate a suitable brake either with or without optional panels.

In some applications it is common to use a different torque rating for the brake. A crane trolley is an example where a 50% brake is typical. A crane hoist typically employs a 125% or a 150% brake.

A few applications require a thorough analysis of the brake and the system. The items which must be considered, together with data and formulae, begin on page 11.

Detailed descriptions of standard and optional features of C-H 505 and 506 brakes follow.

AISE AND NEMA STANDARDS

Brakes conform to AISE and NEMA standards for mill motors. These standards prescribe items such as: wheel diameters and widths, torque increments, height of wheel centerline, mounting dimensions, voltage and current values for release and set, etc. For mill motors, these same standards also fix wheel offsets, hoists, and mounting centerlines between the motor and the brake. Dimensions and drawings of standard brakes with respect to mill motors

SIZE, TYPE AND DUTY CYCLE

Brakes are categorized by the factors of: 1) size, wheel diameter, 2) type, power supply to coil, and 3) duty cycle, coil time-on time-off. These are summarized in the "Selection Table" on page 4.

SIZE - See "Selection Table".

TYPE - Brakes are designated as series or shunt. Series brakes have their coils in the armature circuit of a D-c motor. Shunt brakes have their coils separately energized from a D-c source. The separate supply may be A-c if an optional rectifier panel is used. (page 3).

DUTY CYCLE - The time-on time-off of a brake coil determines its duty cycle. The duty cycle definitely affects the maximum torque rating of a brake, and the following will illustrate this.

Given a fixed volume for the coil, wattage dissipation limits the time the coil can be energized without overheating. This is analogous with mill motor ratings, and the duty cycle of brakes is purposely selected to coincide with mill motor standards.

A coil energized for a short period can carry relatively high currents and compress a "stiff" torque spring. With this spring as a reference, the torque rating is established as the practical maximum for this cycle. Standards are: series 1/2 hour, and shunt intermittent. For longer cycles, the coil can carry less current, compress a "less-stiff" spring, and brake torque must be reduced. Series 1 hour ratings are reduced to 65% of 1/2 hour brakes, and shunt continuous ratings are reduced to 75% of intermittent brakes. Shunt applications which use an auxiliary protecting panel (either A-c or D-c) can have intermittent ratings for all applications if these panels incorporate a forcing and protecting circuit. See page 3. From these considerations, standard duty cycles are listed below.

1. Series, D-c motor only. 505 only.

- 1/2 hour duty, or crane duty. The coil carries 100% of full load armature current for 1/2 hour without overheating. This corresponds to 1 minute on, 2 minutes off, or 1/3 time duty.
- 1 hour duty, or mill duty. The coil carries 100% of full load armature current for 1 hour without overheating. This corresponds to 1 minute on, 1 minute off, or 1/2 time duty.
- C-H and NEMA standards are that series brakes will release at 40% and set at 10% of full load armature current.

2. Shunt, D-c supply, A-c or D-c motor.

- Intermittent, or 1 hour shunt. The coil and its permanent series resistance are across 100% of line voltage for 1 hour without overheating.
- Continuous, or 8 hour shunt. The coil and its permanent series resistance are across 100% of line voltage for 8 hours (considered to be continuously) without overheating.
- With optional coil protective panel. (See page 3). The coil circuit is across 100% of line voltage continuously without overheating. Torque rating is the same as intermittent duty brakes.
- C-H and NEMA standards are that shunt brakes will

CH-000481



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HEAVY DUTY MAGNETIC BRAKES

505 Electro-Mechanical

506 Electro-Hydraulic

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SIZE, TYPE AND DUTY CYCLE (Continued)

3. Shunt, A-c supply, A-c or D-c motor, A-c rectifier panel.
 - a. Panel for 8" through 23" brakes. See below. The optional panel for these sizes includes the protecting circuit and a rectifier. The panel and the coil circuit can be continuously energized at 100% of A-c supply voltage without overheating. Torque rating is the same as for intermittent duty.
 - b. Panel for 30" brakes. See below. This provides D-c from an A-c supply, but without the protecting feature. Therefore brakes are rated either intermittent or continuous. The panel and the coil circuit, at 100% of the A-c supply voltage, can be energized without overheating, for 1 hour for intermittent duty, or continuously for continuous duty.
 - c. C-H and NEMA standards are that brakes will operate at 85% of the A-c supply voltage.

WHEELS

C-H brake wheels are made of specially formulated ductile iron. This has friction characteristics similar to cast iron, and shock and strength characteristics like steel. Because C-H wheels are not heat treated or carburized, they retain their physical and metallurgical properties at temperatures where wheels made of other materials undergo significant changes in their microstructure. C-H wheels wear evenly and smoothly in the form of fine flakes. For this reason, wheel scoring and lining erosion are significantly reduced.

LININGS

C-H brake linings are made of high grade impregnated asbestos fibers. They are technically called "folded and compressed" linings. The materials used in C-H linings result in a lining which has a constant coefficient of friction under operating conditions as well as long life.

COILS

Coils are made with Class B insulation, and they are NEMA 3 enclosed in stainless steel. Coils have 2 leads (about 4" long), and each lead is supplied with a suitable lug. Coils are reversible so that the leads can point toward or away from the wheel.

MOUNTING

505 and 506 brakes are designed for NEMA 1 mounting (base on horizontal surface). Optionally they are available for NEMA 2 mounting (base on vertical surface, magnet end up). Dimensions are the same for either mounting.

CONSTRUCTION

Structural members are made of ductile iron, except the 30" base, which is a steel weldment. Armatures in 8"-23" brakes are cast steel; 30" armatures are made of laminated steel.

C-H brakes have only 1 true pivot pin (pull rod to armature). By using hardened sockets wherever possible, wear and sticking at pivot points is negligible.

D-c PROTECTIVE PANEL, SHUNT ONLY

In some continuous applications, the required torque is between the intermittent and the continuous rating for a brake. Normally, a larger brake would be selected. As an option, a protective panel which permits using the smaller brake is available. The scheme utilized is below.

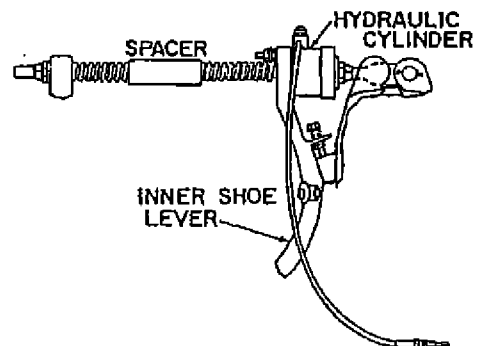
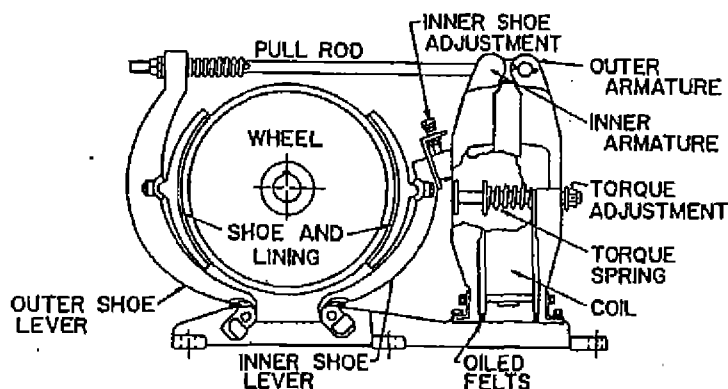
The panel uses a forcing circuit to release the brake and a timer and switch to insert resistance into the coil circuit. This keeps the coil temperature in bounds, and intermittent torque ratings are possible on continuously energized brakes. This same forcing and protecting scheme is used in A-c rectifier panels for 8"-23" brakes.

A-C RECTIFIER PANEL, SHUNT, 8"-23" ONLY

For A-c applications similar to the above, the protective panel is enlarged to include a suitable rectifier. This allows intermittent ratings for continuous applications from an A-c source. D-c voltage is 81% of A-c voltage.

A-c RECTIFIER PANEL, SHUNT, 30" ONLY

This optional panel does not include the forcing/protecting circuit. It only makes it possible to use 30" brakes from an A-c source. Separate series resistance is included, as is an integral 3 phase transformer. D-c voltage is 230 V.



CH-000482

HEAVY DUTY MAGNETIC BRAKES

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505 Electro-Mechanical
506 Electro-Hydraulic

ENCLOSURES

Standard brakes are open type, but they function successfully in moist or dusty environments. For extreme conditions, enclosures are available. They are:

• Partial wheel cover. This is a partial cover over the top of the wheel and extends over the shoes. It is mounted on the pull rod, and is not available for 506.

• NEMA 3. This is a lift-off enclosure which covers everything but the coil and the outer armature. The centerline height of the wheel is unaffected, and the shaft cut-out is included.

• NEMA 4-5 watertight and dusttight. This is a split-case gasketed enclosure without cutouts. The height of the wheel centerline is increased. As an option, a shaft hole, gasket or shaft seal and retainer can be provided. Holes, bolt holes, and gaskets for mounting directly to other machinery are not available.

MANUAL RELEASE, 505 ONLY, 8"-23" ONLY.

Two mechanisms are available. They are:

1. A cam-action lever which is self-returning to the set position. Due to the cam action, a set brake can be released and re-set as desired.
2. A screw-type release, non-self returning. This is a wrench-operated release and must be released and re-set with a wrench.

BRAKE ADJUSTMENT

In any application, torque should be adjusted for best performance rather than maximum. The permissible range of adjustment is:

ALL series brakes: 100% to 50% of $\frac{1}{2}$ HOUR RATING.

ALL shunt brakes: 100% to 50% of INTERMITTENT.

The importance of proper installation and adjustments cannot be overemphasized. Check the nameplate on the brake for the 100% torque setting.

SELECTION TABLE, 505 AND 506 BRAKES

Brake Size	RATED TORQUE, Lb-Ft ① Sprg. (spring set) or Hyd. (hydraulically set)							WR ² of Wheel	Wheel RPM, Max.	WEIGHTS, Lb.			
	D-c						A-c ②			Wheel Only		Brake and Wheel	
	Series (505 Only)		Shunt, 515, 230 or 550 V.				Shunt						
	$\frac{1}{2}$ Hour or Crane	1 Hour or Mill	Intermittent or 1 Hour Shunt	Continuous or 8 Hour Shunt	Continuous with Coil Protective Panel	Continuous with A-c Rectifier Panel	Continuous with A-c Rectifier Panel						
	Sprg.	Sprg.	Sprg. or Hyd.	Sprg.	Hyd.	Sprg. or Hyd.	Sprg. or Hyd.	Lb x Ft ²	RPM	Ship.	Net	Ship.	Net
8"	100	65	100	75	100	100	100	1.1	5,000	18	12	178	150
10"	200	130	200	150	200	200	200	3	4,000	35	25	263	240
13"	550	365	550	400	550	550	550	12	3,180	75	59	510	465
16"	1,000	650	1,000	750	1,000	1,000	1,000	36	2,500	120	102	700	645
19"	2,000	1,300	2,000	1,500	2,000	2,000	2,000	70	2,110	185	160	1,220	1,150
23" 505 only	4,000	2,600	4,000	3,000	—	4,000	4,000	210	1,740	315	290	1,830	1,735
30" 505 only	9,000	6,000	9,000	6,750	—	9,000	9,000 int. 6,750 cont.	880	1,340	1,180	1,100	4,100	3,920

① Actual hydraulically applied torque is dependent only on force on pedal. See page 6.

② 208-240/1/60 or 440-480/1/60 for 8"-23". Same voltages except 3 phase for 30".



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HEAVY DUTY MAGNETIC BRAKES

505 Electro-Mechanical

506 Electro-Hydraulic

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POWER FOR SHUNT BRAKES

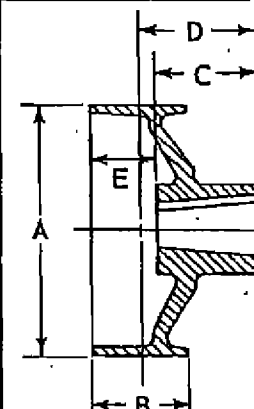
Brake Size	D-c Operated 115, 230, or 550 V.						From A-c Rectifier Panel, 208-240 V. 60 Cycle or 440-480 V. 60 Cycle				From D-c Protective Panel
	Intermittent			Continuous			Separate Permanent Series Resistance	Power, KVA.			
	Separate ① Permanent Series Resistance		Power, KW.	Separate ① Permanent Series Resistance		Power, KW.		Inrush	Sealed	φ	
	Quan.	Type		Quan.	Type						
8"	1	H	.44	1	H	.26	—	1.75	.25	1	Refer To Cutter-Hammer
10"	1	H	.50	1	H	.28	—	1.85	.25	1	
13"	1	H	.66	1	H	.43	—	2.60	.26	1	
16"	1	H	.82	1	H	.49	—	2.82	.26	1	
19"	1	H	1.24	1	H	.60	—	3.22	.41	1	
23"	2	H	1.92	1	H	.79	—	4.17	.51	1	
30"	1	WS	4.50	2	WS	2.95	Int. 1 — WS Box Cont. 2 — WS Box	3.5	3.5	3	

① Resistance data for 230 V. Refer to C-H for other voltages.

SHUNT BRAKES, MAXIMUM SPEEDS OF OPERATION

Brake Size	STANDARD Intermittent or Continuous Partial Voltage Coil and Separate Resistance		OPTIONAL Intermittent Duty Coil Protective Panel ① or A-c Rectifier Panel ①	
	RELEASE, Sec.	SET, Sec.	RELEASE, Sec.	SET, Sec.
8"	.25	.25	.22	.15
10"	.30	.30	.25	.20
13"	.35	.40	.30	.22
16"	.45	.45	.40	.25
19"	.50	.50	.45	.30
23"	.55	.55	.50	.32
30"	.55	.10	.55	.10

① Use of either on all but A-c operated 30" brake allows intermittent duty rating on continuously energized coil circuits. The A-c operated 30" brake is rated either 6,750 lb-ft continuous or 9,000 lb-ft intermittent.



STANDARD WHEEL CASTINGS

Dimensions, Inches										WR2 Lb x Ft ²	Weight Lb.	
A	B	C Max. ①	D Max. ①	Min.	E Min. ①	Max.	Min. Bore		Max. Bore		Ship	Net
8	3 1/2	3	4	2 1/2	2 1/2	2 1/2	1	1	2	1.1	18	12
10	3 1/2	3 1/2	4 1/2	3 1/2	2 1/2	4	1	1	2	3	35	25
13	5 1/2	4 1/2	5 1/2	3 1/2	3 1/2	4 1/2	1	1	3 1/2	12	75	59
		4 1/2	3 1/2		2							
		4 1/2	6		4 1/2							
		4 1/2	4 1/2		2 1/2							
16	6 1/2	4 1/2	3 1/2	3 1/2	1 1/2	5 1/2	3	2 1/2	3 1/2	36	120	102
		5 1/2	6 1/2		4 1/2							
		5	7 1/2		5 1/2							
		5	5		3 1/2							
19	8 1/4	5	7 1/2	5 1/2	6 1/2	7 1/2	3 1/2	3	4 1/2	70	165	160
		5 1/2	8									
23	11 1/2	6	8 1/2	5 1/2	8 1/2	9 1/2	4 1/2	4	5	210	315	290
30	14 1/2	9 1/2	12 1/2	10 1/2	10 1/2	10 1/2	5 1/2	5	7	880	1,180	1,100

① Standard castings have hub dimensions of C Max., D Max., and E Min. Refer to C-H for wheels from special castings.

CH-000484

HEAVY DUTY MAGNETIC BRAKES

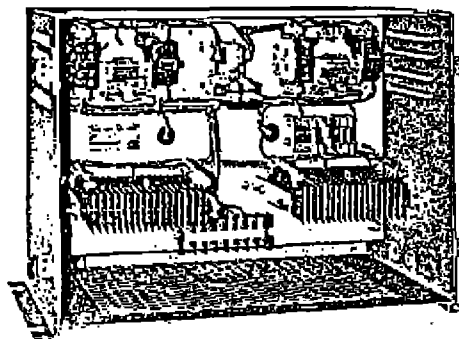
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505 Electro-Mechanical
506 Electro-Hydraulic

A-C RECTIFIER PANEL, APPROXIMATE DIMENSIONS

Brake Size	Mounting	Dimensions, Inches			Weights, Lb.	
		Height	Width	Depth	Ship.	Net
8"	Floor	24	16 $\frac{1}{4}$	11 $\frac{1}{2}$	95	85
10"						
13"						
16"						
19"	Floor	28	16 $\frac{1}{4}$	11 $\frac{1}{2}$	110	98
23"						
30"	Panel (Not Shown)	Wall	30 $\frac{3}{16}$	42 $\frac{1}{16}$	11 $\frac{1}{16}$	180
	① Separate Resistance (Not Shown)	Floor	6	17 $\frac{1}{4}$	12	28

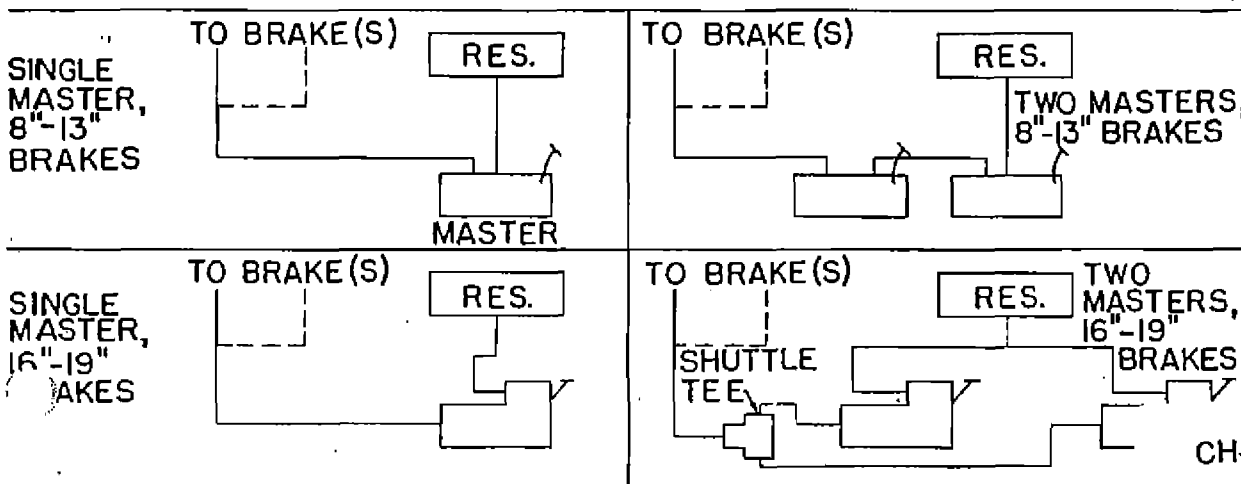


① 1 supplied for intermittent duty, 2 supplied for continuous duty.

PEDAL AND MASTER STATION DATA, 506 BRAKES

Brake Size	Torque, Lb-Ft				Pedal Data for Service Torque			Master Station
	Park (Spring Set)			Service (hydraulically applied)	Force (1 or 2 Brakes), Pounds	Stroke, Inches		
	D-c	D-c with coil protective panel	A-c			1 Brake	2 Brakes	
8"	.75	100	100	100	20	1½	3¾	Small
10"	150	200	200	200	30	2	4¼	Small
13"	400	550	550	550	60	2¾	4½	Small
16"	750	1,000	1,000	1,000	60	3¾	7¼	Large, 18" Lever
19"	1,500	2,000	2,000	2,000	80	6	12	Large, 24" Lever

HYDRAULIC SCHEMATICS, 506 BRAKES



CH-000485

① All necessary fittings supplied. Each brake is equipped with 100' of $\frac{1}{4}$ " copper tubing. Each master station is equipped with 2-30" flexible hoses. Each installation is provided with 1 gal. fire-resistant brake fluid (CH #637-796 or equal to Nyvac No. 20). When 2



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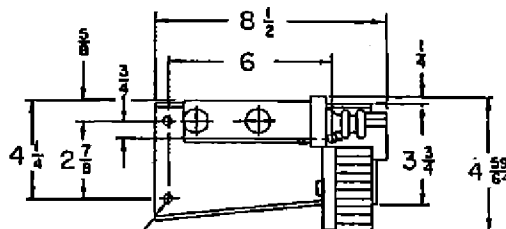
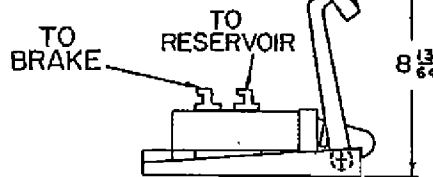
HEAVY DUTY MAGNETIC BRAKES

505 Electro-Mechanical

506 Electro-Hydraulic

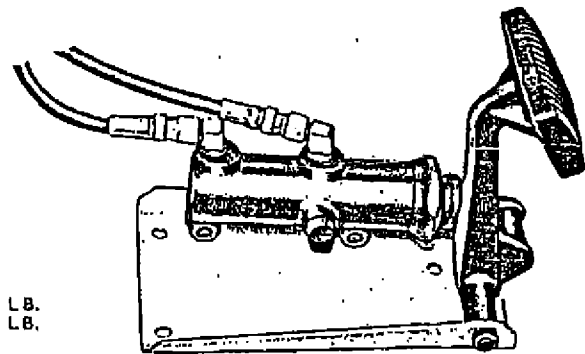
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APPROXIMATE DIMENSIONS, 506 RESERVOIR AND MASTER STATIONS

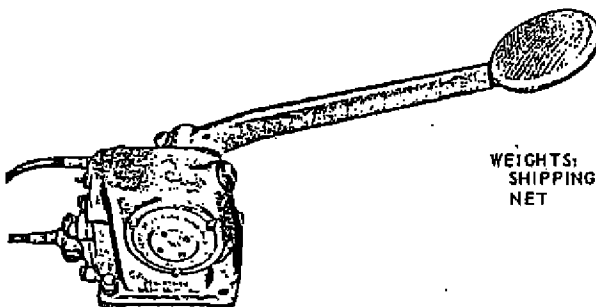
(3) $\frac{11}{32}$ MTG. HOLES

MASTER STATION
8", 10" & 13" BRAKES
FLOOR MTG. ONLY

WEIGHTS:
SHIPPING - 11 LB.
NET - 9 LB.

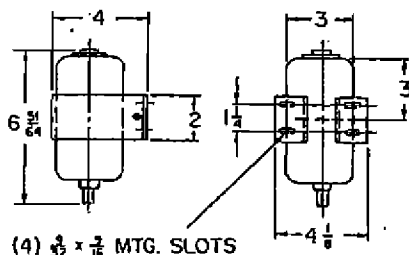


SMALL MASTER STATION
FOR 8-13" BRAKE(S)



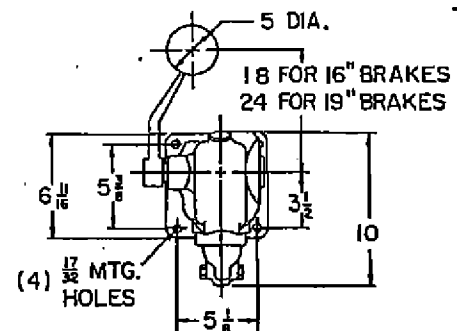
LARGE MASTER STATION
FOR 16 AND 19" BRAKE(S)

WEIGHTS:
SHIPPING - 14 LB.
NET - 12 LB.



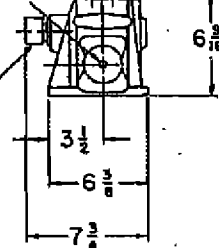
RESERVOIR
MUST BE AT HIGHEST
POINT IN SYSTEM

WEIGHTS:
SHIPPING - 6 LB.
NET - 4 LB.



TO BRAKE TO RESERVOIR

SERRATED SHAFT.
PEDAL CAN BE
ROTATED



MASTER STATION
16" & 19" BRAKES
SUITABLE FOR MTG.
IN ANY PLANE

CH-000486

HEAVY DUTY MAGNETIC BRAKES

9/15/66



505 Electro-Mechanical 506 Electro-Hydraulic

APPROXIMATE DIMENSIONS, 505/506 BRAKES.

Dimensions with * apply only to AISE standards established for indicated motors.

SERIES BRAKES FOR 400 AND 600 FRAME MOTORS

Motor Frame No.	MOTOR DATA				WHEEL DIMENSIONS, (inches)					LOCATION DIMENSIONS, (inches)												CLEARANCE DIMENSIONS, (inches)											
	Duty and Rated HP	Rated RPM	Rated Torque, (lb-ft)	Shaft Torque, (lb-ft)	B	C*	D*	E*	F*	G*	H*	CC	N	P	AA	AA*	Q*	R	S	T	U	V	W	X	Y	Z							
8	402	1/2 hr 6.0hp	750	46	100	3.75	3	4	2.38	1.750 1.745	1/4	16	1/4	7	8.25	4.25	2.88	3.89	.89	3.25	13.63	15.5	.88	.75	3.88	16.81	6.5	6.5	7.38	15.38	7.13	5	
	402	1 hr 5hp	900	29	65	3.75	3	4	2.38	1.750 1.745	1/4	16	1/4	7	8.25	4.25	2.88	3.89	.89	3.25	13.63	15.5	.88	.75	3.88	16.81	6.5	6.5	7.38	15.38	7.13	5	
	402	1 hr 10hp	675	78	100	3.75	3	4	2.38	1.750 1.745	1/4	16	1/4	7	8.25	4.25	2.88	3.89	.89	3.25	13.63	15.5	.88	.75	3.88	16.81	6.5	6.5	7.38	15.38	7.13	5	
10	601	1/2 hr 12.5hp	620	114	200	3.75	3.5	4.25	2.38	2.000 1.995	1/2	17.42	1/2	8.38	9.25	5	3.13	3.94	.89	4	15.75	17.59	1.13	.75	4.88	18.44	8	7.88	8.63	17	7.38	5.63	
	601	1 hr 10hp	725	73	130	3.75	3.5	4.25	2.38	2.000 1.995	1/2	17.42	1/2	8.38	9.25	5	3.13	3.94	.89	4	15.75	17.59	1.13	.75	4.88	18.44	8	7.88	8.63	17	7.38	5.63	
	601	1 hr 15hp	560	178	200	3.75	3.5	4.25	2.38	2.000 1.995	1/2	17.42	1/2	8.38	9.25	5	3.13	3.94	.89	4	15.75	17.59	1.13	.75	4.88	18.44	8	7.88	8.63	17	7.38	5.63	
13	806	1/2 hr 33hp	515	336	550	5.75	4	5	2.13	2.500 2.495	1/2	20.31	1/2	9.88	10.5	5.5	4.5	5.5	.81	5.75	19	21	1	.88	6.75	21.25	9.88	9.5	10.38	19.88	8.5	6.75	
	806	1 hr 25hp	575	238	365	5.75	4	5	2.13	2.500 2.495	1/2	20.31	1/2	9.88	11	5.83	4.5	5.5	.81	5.75	19	21	1	.88	6.75	21.25	9.88	9.5	10.38	19.88	8.5	6.75	
	806	1 hr 45hp	470	563	550	5.75	4.5	5.38	2.5	3.000 2.995	1/2	20.31	1/2	9.88	11	5.83	4.5	5.5	.81	5.75	19	21	1	.88	6.75	21.25	9.88	9.5	10.38	19.88	8.5	6.75	
16	610	1/2 hr 65hp	445	765	1,000	6.75	4.5	5.5	3.13	3.250 3.245	1/2	22.63	1/2	12.13	12.75	6.25	5.38	6.5	1.06	7.5	22.75	25	1.25	1	8.75	23.88	12.25	12	12.38	21.88	8.5	7.75	
	610	1 hr 50hp	500	575	650	6.75	4.5	5.5	3.13	3.250 3.245	1/2	22.63	1/2	12.13	12.75	6.25	5.38	6.5	1.06	7.5	22.75	25	1.25	1	8.75	23.88	12.25	12	12.38	21.88	8.5	7.75	
	612	1/2 hr 100hp	420	1,220	2,000	6.75	5	7.5	3.13	3.625 3.620	1/2	26.38	1/2	13.25	14.25	6.75	6.5	7.88	1.06	9.25	25.63	28	1.38	1.13	10.63	27.63	14.5	14.5	14.88	26.5	10.13	9.25	
19	612	1 hr 75hp	475	830	1,300	6.75	5	7.5	3.13	3.625 3.620	1/2	26.38	1/2	13.25	14.25	6.75	6.5	7.88	1.06	9.25	25.63	28	1.38	1.13	10.63	27.63	14.5	14.5	14.88	26.5	10.13	9.25	
	612	1 hr 135hp	400	1,770	2,000	6.75	5	7.5	3.13	3.625 3.620	1/2	26.38	1/2	13.25	14.25	6.75	6.5	7.88	1.06	9.25	25.63	28	1.38	1.13	10.63	27.63	14.5	14.5	14.88	26.5	10.13	9.25	
	612	1 hr 180hp	460	1,140	1,300	6.75	5	7.5	3.13	3.625 3.620	1/2	26.38	1/2	13.25	14.25	6.75	6.5	7.88	1.06	9.25	25.63	28	1.38	1.13	10.63	27.63	14.5	14.5	14.88	26.5	10.13	9.25	
23	816	1/2 hr 200hp	400	2,620	4,000	11.25	5.5	8.25	2.63	4.625 4.620	1/2	30.75	1/2	15.88	17.25	9	8	9.5	1.31	11.75	30.38	-	1.5	1.13	13.25	31.75	16.13	16.75	17.38	30.38	11.38	10.50	
	816	1 hr 150hp	450	1,750	2,600	11.25	5.5	8.25	2.63	4.625 4.620	1/2	30.75	1/2	15.88	17.25	9	8	9.5	1.31	11.75	30.38	-	1.5	1.13	13.25	31.75	16.13	16.75	17.38	30.38	11.38	10.50	
	816	1 hr 265hp	385	3,610	4,000	11.25	6	8.75	3.13	5.000 4.995	1/2	30.75	1/2	15.88	17.25	9.5	8	9.5	1.31	11.75	30.38	-	1.5	1.13	13.25	31.75	16.13	16.75	17.38	30.38	11.38	10.50	
30	824	1/2 hr 360hp	340	5,550	9,000	14.25	6.75	10.25	3.13	5.875 5.870	1/2	-	-	20.75	18.75	8.5	9.5	11.53	1.56	15	40.38	-	2	1.38	17	39.5	24.25	22.75	29.5	41.88	4.22	10.75	
	824	1 hr 275hp	370	3,980	6,750	14.25	6.75	10.25	3.13	5.875 5.870	1/2	-	-	20.75	18.75	8.5	9.5	11.53	1.56	15	40.38	-	2	1.38	17	39.5	24.25	22.75	29.5	41.88	4.22	10.75	
	824	1 hr 500hp	310	8,150	9,000	14.25	7.25	10.75	3.63	6.250 6.245	1/2	-	-	20.75	18.75	9	9.5	11.53	1.56	15	40.38	-	2	1.38	17	39.5	24.25	22.75	29.5	41.88	4.22	10.75	
30	824	1 hr 375hp	340	5,600	6,000	14.25	6.75	10.25	3.13	5.875 5.870	1/2	-	-	20.75	18.75	8.5	9.5	11.53	1.56	15	40.38	-	2	1.38	17	39.5	24.25	22.75	29.5	41.88	4.22	10.75	
	824	1 hr 660hp	300	11,500	9,000	14.25	9.25	10.75	3.63	7.000 6.995	1/2	-	-	20.75	19.25	8.5	9.5	11.53	1.56	15	40.38	-	2	1.38	17	39.5	24.25	22.75	29.5	41.88	4.22	10.75	

* Brakes required with 624 frame motor used at rated conditions.

SERIES BRAKES FOR 800 FRAME MOTORS

Bucke Size Number A	MOTOR DATA				WHEEL DIMENSIONS, (inches)				LOCATION DIMENSIONS, (inches)												CLEARANCE DIMENSIONS, (inches)											
	Frame No.	Duty and Rated HP	Rated RPM	Rated Torque, (lb-ft)	B	C*	D*	E*	F*	G*	H*	CC	N	P	AA	AA*	Q	R	S	T	U	V	W	X	Y	Z						
8	802A	1/2 hr 6.0hp	750	46	100	3.75	3	4	2.38	1.750 1.745	16	1/4	7	8.25	4.25	2.88	3.89	.89	3.25	13.63	15.5	.88	.75	3.88	16.81	6.5	6.5	7.38	15.38	7.13	5	
	802B	1 hr 5hp	900	29	65	3.75	3	4	2.38	1.750 1.745	16	1/4	7	8.25	4.25	2.88	3.89	.89	3.25	13.63	15.5	.88	.75	3.88	16.81	6.5	6.5	7.38	15.38	7.13	5	
10	802C	1/2 hr 10hp	675	78	100	3.75	3	3.75	1.88	1.750 1.745	17.42	1/2	8.38	9	4.25	3.13	3.94	.89	4	15.75	17.59	1.13	.75	4.88	18.44	8	7.88	8.63	17	7.38	5.63	
	601	1 hr 10hp	800	56	130	3.75	3	4.25	2.38	2.000 1.995	17.42	1/2	8.38	9.25	5	3.13	3.94	.89	4	15.75	17.59	1.13	.75	4.88	18.44	8	7.88	8.63	17	7.38	5.63	
13	601	1/2 hr 25hp	580	235	550	5.75	3.50	4.38	1.56	2.000 1.995	20.31	1/2	9.88	9.88	5.5	4.5	5.5	.81	5.75	19	21	1	.88	6.75	21.25	9.88	9.5	10.38	19.88	8.5	6.75	
	806	1 hr 20hp	650	161	365	5.75	4	4.88	2	2.500 2.495	20.31	1/2	9.88	10.38	5.5	4.5	5.5	.81	5.75	19	21	1	.88	6.75	21.25	9.88	9.5	10.38	19.88	8.5	6.75	
16	808	1/2 hr 39hp	500	410	550	5.75	4	4.88	2	2.500 2.495	20.31	1/2	9.88	10.38	5.5	4.5	5.5	.81	5.75	19	21	1	.88	6.75	21.25	9.88	9.5	10.38	19.88	8.5	6.75	
	808	1 hr 30hp	575	274	365	5.75	4	4.88	2	2.500 2.495	20.31	1/2	9.88	10.38	5.5	4.5	5.5	.81	5.75	19	21	1	.88	6.75	21.25	9.88	9.5	10.38	19.88	8.5	6.75	
19	810	1/2 hr 65hp	450	760	1,000	6.75	4.5	6.25	2.68	3.000 2.995	22.63	1/2	12.13	12.75	6.25	5.38	6.5	1.06	7.5	22.75	25	1.25	1	8.75	23.88	12.25	12	12.38	21.88	8.5	7.75	
	810	1 hr 50hp	525	500	610	6.75	4.5	6.25	2.68	3.000 2.995	22.63	1/2	12.13	12.75	6.25	5.38	6.5	1.06	7.5	22.75	25	1.25	1	8.75	23.88	12.25	12	12.38	21.88	8.5	7.75	
23	810	1/2 hr 90hp	440	1,075	2,000	6.75	4.5	7	2.62	3.250 3.245	26.38	1/2	13.25	14.25	6.25	6.5	7.88	1.06	9.25	25.63	28	1.38	1.13	10.63	27.63	14.5	14.5	14.88	26.5	10.13	9.25	
	812	1 hr 70hp	500	735	1,300	6.75	5	7.5	3.13	3.625 3.620	26.38	1/2	13.25	14.25	6.25	6.5	7.88	1.06	9.25	25.63	28	1.38	1.13	10.63	27.63	14.5	14.5	14.88	26.5	10.13	9.25	
30	816	1/2 hr 135hp	420	1,630	2,000	6.75	5	7.5	3.13	3.625 3.620	26.38	1/2	13.25	14.25	6.25	6.5	7.88	1.06	9.25	25.63	28	1.38	1.13	10.63	27.63	14.5	14.5	14.88	26.5	10.13	9.25	
	816	1 hr 100hp	475	1,110	2,800	6.75	5	7.5	3.13	3.625 3.620	26.38	1/2	13.25	14.25	6.25	6.5	7.88	1.06	9.25	25.63	28	1.38	1.13	10.63	27.63	14.5	14.5	14.88	26.5	10.13	9.25	
30	816	1/2 hr 200hp	400	2,620	4,000	11.25	5.5	8	1.88	4.500 4.495	30.75	1/2	15.88	17.25	9	8	9.5	1.31	11.75	30.38	-	1.5	1.13	13.25	31.75	16.13	16.75	17.38	30.38	11.38	10.5	
	816	1 hr 150hp	450	1,715	2,600	11.25	5.5	8.25	2.62	4.625 4.620	30.75	1/2	15.88	17.25	9	8	9.5	1.31	11.75	30.38	-	1.5	1.13	13.25	31.75	16.13	16.75	17.38	30.38	11.38	10.5	
30	816	1/2 hr 265hp	380	3,900	4,000	11.25	6	8.75	3.13	5.000 4.995	30.75	1/2	15.88	17.25	9.5	8	9.5	1.31	11.75	30.38	-	1.5	1.13	13.25	31.75	16.13	16.75	17.38	30.38	11.38	10.5	
	816	1 hr 200hp	450	2,340	2,600	11.25	5.5	8.25	2.62	4.625 4.620	30.75	1/2	15.88	17.25	9	8	9.5	1.31	11.75	30.38	-	1.5	1.13	13.25	31.75	16.13	16.75	17.38	30.38	11.38	10.5	
30	824	1/2 hr 375hp	360	4,740	9,000	14.25	6.75	10.25	3.63	6.250 6.245	30.75	1/2	18.75	19.5	9.5	9.5	11.53	1.56	15	40.38	-	2	1.38	17	39.5	24.25	22.75	29.5	41.88	4.22	10.75	
	824	1 hr 250hp	410	3,700	6,000	14.25	6.75	10.25	3.63	6.250 6.245	30.75	1/2	18.75	19.5	9.5	9.5	11.53	1.56	15	40.38	-	2	1.38	17	39.5	24.25	22.75	29.5	41.88	4.22	10.75	



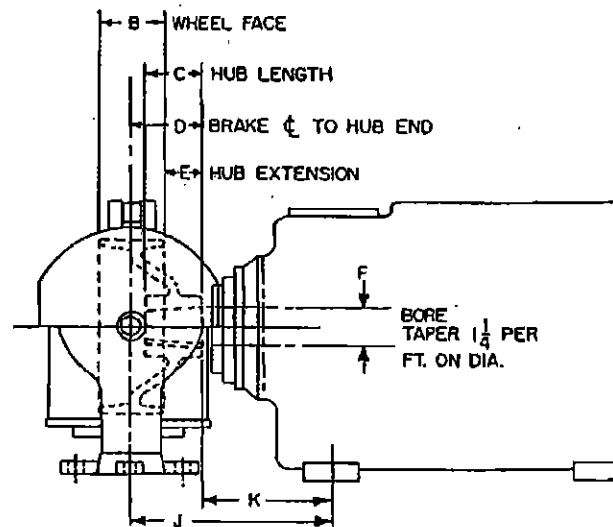
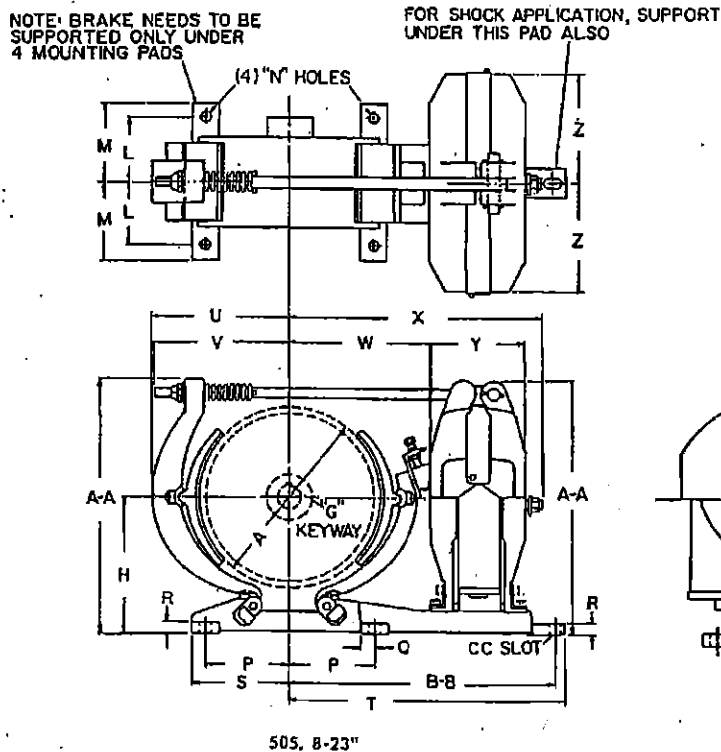
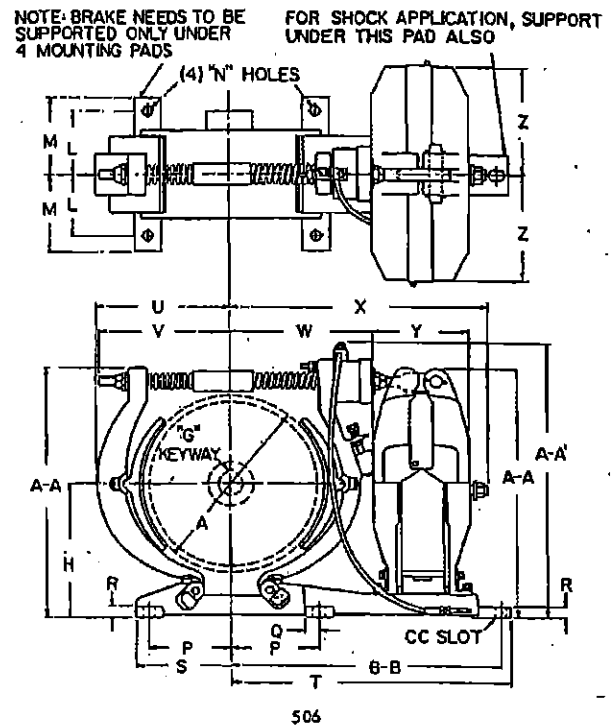
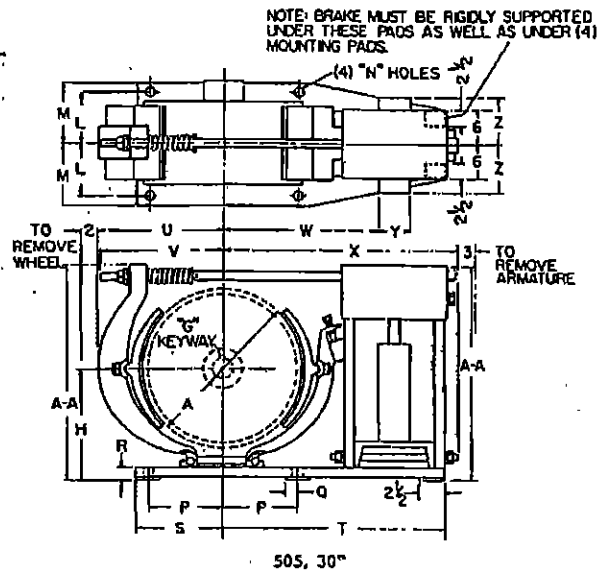
9/15/66

HEAVY DUTY MAGNETIC BRAKES

505 Electro-Mechanical

506 Electro-Hydraulic

TECHNICAL
INFORMATION
PUBLICATION
505/506



TYPICAL BRAKE AND
STANDARD MOUNTING FOR MILL MOTOR
(SHIM BRAKE AS REQUIRED)

SEE PAGE 4 FOR DIMENSIONS

CH-000488

— CUTLER-HAMMER

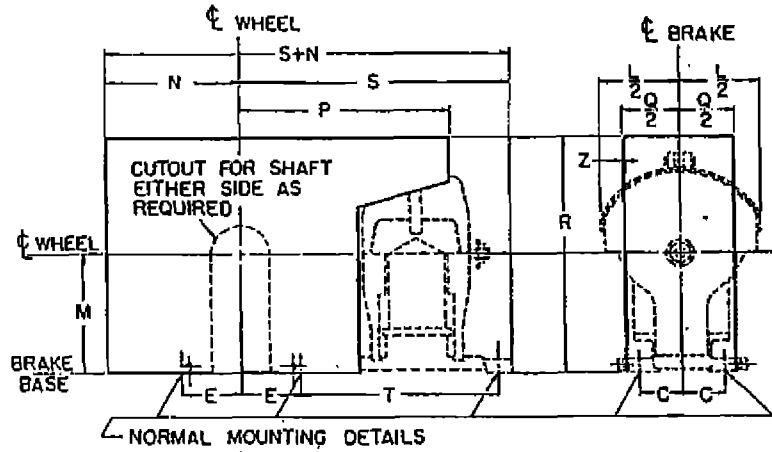
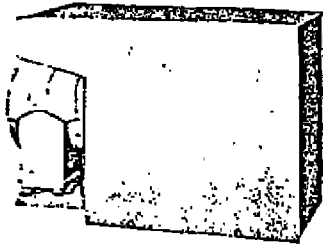
HEAVY DUTY MAGNETIC BRAKES

9/15/66



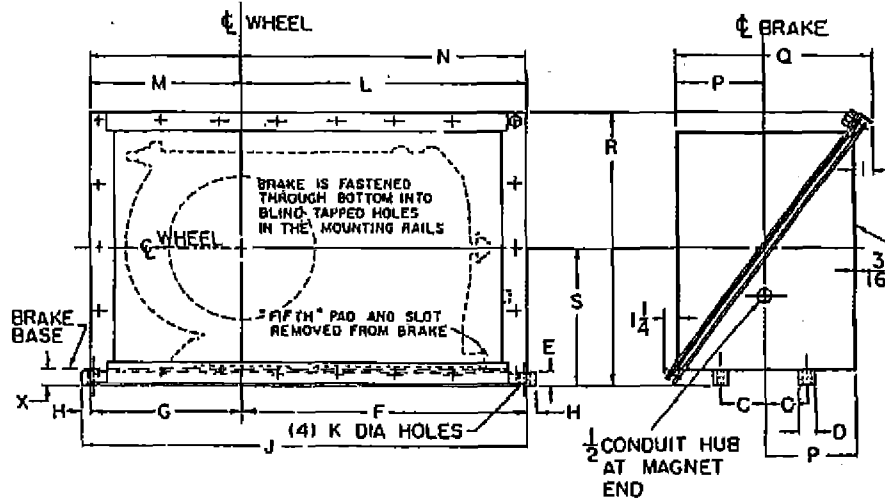
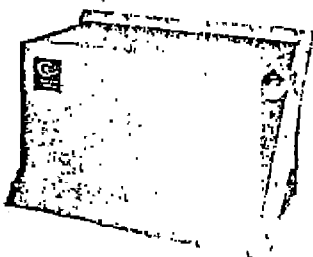
505 Electro-Mechanical
506 Electro-Hydraulic

APPROXIMATE DIMENSIONS,
EMA 3 ENCLOSED



Brake Size	DIMENSIONS, inches												
	C	E	L 2	M	N	P	Q 2	R		S	S + N	T	Z
								505	506				
8"	2 $\frac{1}{4}$	3 $\frac{1}{4}$	5	7	7 $\frac{1}{4}$	13	3 $\frac{1}{2}$	14 $\frac{1}{2}$	16 $\frac{1}{2}$	16 $\frac{1}{16}$	24 $\frac{1}{16}$	16	$\frac{1}{16}$
10"	3 $\frac{1}{4}$	4	5 $\frac{1}{4}$	8 $\frac{1}{4}$	9 $\frac{1}{4}$	14 $\frac{1}{4}$	4	16 $\frac{1}{4}$	18 $\frac{1}{4}$	18 $\frac{1}{16}$	27 $\frac{1}{16}$	17 $\frac{1}{4}$	$\frac{1}{16}$
13"	4 $\frac{1}{4}$	5 $\frac{1}{4}$	6 $\frac{1}{4}$	9 $\frac{1}{4}$	11	17	5 $\frac{1}{4}$	19 $\frac{1}{4}$	21 $\frac{1}{4}$	21 $\frac{1}{16}$	32 $\frac{1}{16}$	20 $\frac{1}{16}$	$\frac{1}{16}$
16"	5 $\frac{1}{4}$	7 $\frac{1}{4}$	7 $\frac{1}{4}$	12 $\frac{1}{4}$	13 $\frac{1}{4}$	19 $\frac{1}{4}$	6 $\frac{1}{4}$	23 $\frac{1}{4}$	25 $\frac{1}{4}$	23 $\frac{1}{16}$	37 $\frac{1}{16}$	22 $\frac{1}{4}$	$\frac{1}{16}$
19"	6 $\frac{1}{4}$	9 $\frac{1}{4}$	9 $\frac{1}{4}$	13 $\frac{1}{4}$	15 $\frac{1}{4}$	23	8	26 $\frac{1}{4}$	28 $\frac{1}{4}$	27 $\frac{1}{16}$	43 $\frac{1}{16}$	26 $\frac{1}{4}$	$\frac{1}{16}$
23"	8	11 $\frac{1}{4}$	10 $\frac{1}{4}$	15 $\frac{1}{4}$	19 $\frac{1}{4}$	26 $\frac{1}{4}$	9 $\frac{1}{4}$	31 $\frac{1}{4}$	—	31 $\frac{1}{16}$	51	30 $\frac{1}{4}$	$\frac{1}{16}$

APPROXIMATE DIMENSIONS,
NEMA 4-5 ENCLOSED



Brake Size	DIMENSIONS, inches																
	C	D	E	F	G	H	J	K	L	M	N	P	Q	R		S	X
8"	2 1/4	1 1/4	1 1/4	17 1/4	8 1/4	1	28 1/4	1 1/4	18	9	27	5 1/4	13 1/4	17 1/4	19 1/4	8 1/4	1 1/4
10"	3 1/4	1 1/4	1 1/4	19 1/4	10 1/4	1	31 1/4	1 1/4	19 1/4	10 1/4	30	6 1/4	14 1/4	19 1/4	21 1/4	10 1/4	1 1/4
13"	4 1/4	1 1/4	1 1/4	22 1/4	12 1/4	1	36 1/4	1 1/4	22 1/4	12 1/4	34 1/4	7 1/4	17 1/4	23 1/4	25 1/4	11 1/4	1 1/4
16"	5 1/4	3	2	24 1/4	14 1/4	1 1/4	41 1/4	1 1/4	24 1/4	14 1/4	39 1/4	8 1/4	19 1/4	27 1/4	29 1/4	14 1/4	2 1/4
19"	6 1/4	3	2	28 1/4	16 1/4	1 1/4	48 1/4	1 1/4	29	17	46	9 1/4	22 1/4	30 1/4	32 1/4	15 1/4	2 1/4
23"	8	3	2	33	20 1/4	1 1/4	56 1/4	1 1/4	33	20 1/4	53 1/4	11 1/4	24 1/4	35 1/4	—	18 1/4	2 1/4

CH-000489



9/15/66

HEAVY DUTY MAGNETIC BRAKES

505 Electro-Mechanical

506 Electro-Hydraulic

TECHNICAL

INFORMATION

PUBLICATION

505/506

ENGINEERED APPLICATIONS

Many brake applications are such that a brake should be selected on considerations involving factors other than motor torque. The purpose of this section is to present the factors which enter into such a selection, and to provide the guide lines which should be used.

FUNDAMENTAL

A brake converts kinetic energy into heat. During the stopping cycle, this heat is absorbed almost entirely by the brake wheel alone. It can be approximated that the linings absorb little heat, and that heat dissipated during the stop is negligible. The heat must then be dissipated during the time the wheel is rotating.

WHEELS AND LININGS

For long-time successful use, C-H brakes are rated and selected to limit the surface temperature of the wheel (and therefore lining temperature) to about 400 F. Linings contain organic binders which begin to deteriorate at about 450 F., and the asbestos itself begins to lose its 14% water of crystallization at about 500 F. Linings which are run at higher temperatures simply wear away more quickly and require more frequent adjustment and replacement.

Heat Dissipation

Wheels rotating at a peripheral velocity of 2,500 fpm dissipate energy (heat) at about 300 ft-lb per minute per square inch of wheel surface area. This decreases linearly by about 50% when velocity drops below 1,000 fpm. Factors which increase or decrease air circulation around the wheel will alter the rate(s) accordingly. Most applications are such that the dissipation rate of the wheel is the important consideration. In these applications, small amounts of heat are absorbed and dissipated frequently, and the wheel neither cools to ambient nor exceeds permissible temperatures.

Absorption capacity

In many applications the heat-absorbing capacity of the wheel becomes dominant. For example: to infrequently stop a high energy system in a short time (consider a centrifuge) requires the absorption of a large block of energy during "one long stop". It is approximated that no heat is dissipated during the

stop. The absorption figure is about 2,100 ft-lb per square inch of wheel surface area (for a wheel initially at a 104 F. ambient, or 40 C., and finally at 400 F.). The wheel must cool to ambient temperature before the next "long stop".

By comparing dissipation rates and absorption capacity vs. the non-stopping parts of the cycle, it can be seen that the time between "long" stops varies from 7x stopping time (wheel spinning rapidly) to 14x stopping time (wheel spinning slowly or brake set). Thus the order of cycle time can be on the order of minutes rather than hours.

WHEEL HEAT CAPACITY DATA

Wheel (Brake) Size	Wheel Surface Area Sq. In.	At Peripheral Velocity of 2,500 Feet Per Minute:		Heat Absorption Capacity During One Long Stop Ft-Lb
		RPM	Heat Dissipation, Ft-Lb/Minute	
8"	81.5	1190	24,500	163,000
10"	117	1040	35,400	236,000
13"	236	735	70,500	470,000
16"	338	595	101,500	678,000
19"	521	500	156,500	1,040,000
23"	815	415	244,000	1,625,000
30"	1,350	318	354,000	2,360,000

For making calculations, data from previous pages can be found as follows:

torque ratings page 4

release/set times page 5

COILS

From an application standpoint, series brakes have a limited coil selection range. Since the coil is in the motor circuit, the power to the coil is a function of the entire motor armature circuit. In addition, industry standards require series brakes to release on 40% and to stay released down to 10% of full load motor current. It is because of the coil design parameters plus industry standards that series brakes have the aforementioned limitations.

Shunt brakes, however, have a relatively wide range of coil selection. Where intermittent ratings are required on an otherwise continuous applications, or where release times must be shortened, a coil protective panel or an A-c rectifier panel can be employed. See page 3.

HEAVY DUTY MAGNETIC BRAKES

9/15/66



505 Electro-Mechanical
506 Electro-Hydraulic

ALCULATIONS

All applications should have brake sizing verified by considering time and distance to stop versus energy in the system at the time the brake is set. The generalized formula is:

$$t = t_a + t_d = t_a + \frac{120 KE}{2\pi TN_b} \quad (1)$$

where t = time, seconds, to stop the system from the time the coil circuit is de-energized.

t_a = time, seconds, for the brake to set

t_d = deceleration time, seconds

KE = total kinetic energy, ft-lb, in the system at the time the brake sets

T = retarding torque, total available, lb-ft, consists of brake torque, friction, dynamic braking, overhauling torque, etc.

N_b = rpm of the brake wheel. Usually considered base speed

In most calculations, the retarding torque " T " is taken to be that of the brake LESS the overhauling torque. Friction and dynamic braking are usually added. This indicates a brake on the safe side. If late stopping/spotting is required, these factors should be included. From equation (1), it is simple to calculate drift, stopping distance, etc.

To further simplify calculations, manufacturers of rotating machinery and other elements usually list a term such as " WR^2 " or " WK^2 " for their products.

This term consists of the weight (in pounds) of the moving part(s) multiplied by the radius of gyration (in feet) squared. Equation (1) is modified to:

$$t = t_a + \frac{N_b (\sum \text{rotating } WR^2 + \sum \text{linear } WR^2)}{308T} \quad (2)$$

$$t = t_a + \frac{N_b (\text{sum of rotating } WR^2 + \text{sum of "linear } WR^2")}{308T}$$

Two other equations are useful.

Equation (3) converts the WR^2 of an element rotating at other than base speed to the base speed:

$$\text{equivalent } WR^2 = (WR^2)_e \left(\frac{N_e}{N_b} \right)^2 \quad (3)$$

Equation (4) converts linear kinetic energy to an equivalent system rotating at base speed:

$$\text{equivalent } WR^2 = w \left(\frac{V}{2\pi N_b} \right)^2 \quad (4)$$

where: w = weight, lb, of an element with linear motion.

$(WR^2)_e$ = natural factor of element rotating at other than base speed, lb-ft².

N_e = rpm of mass rotating at other than base speed.

V = linear velocity, fpm.

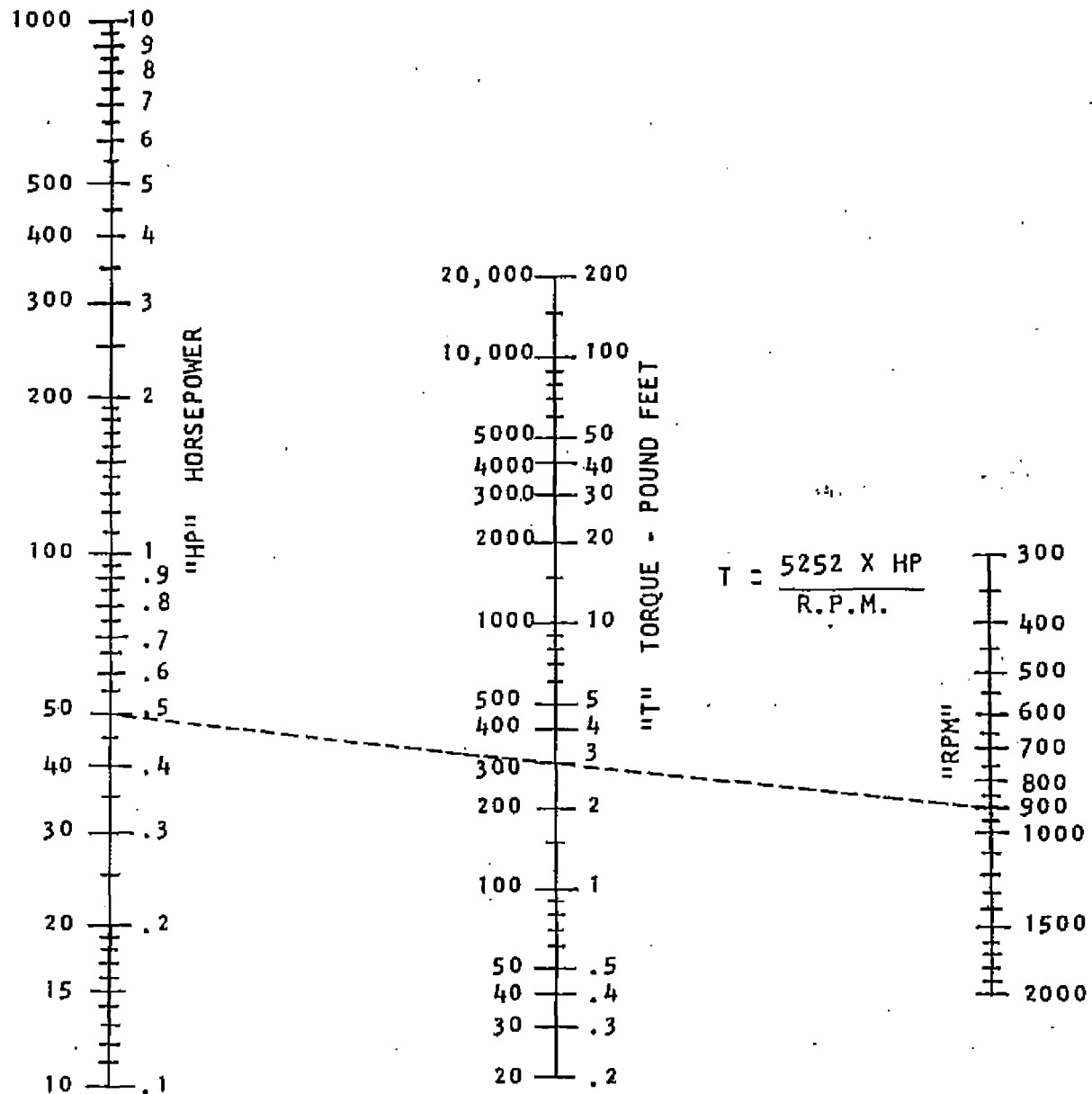


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HEAVY DUTY MAGNETIC BRAKES

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INFORMATION
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SELECTOR CHART FOR DETERMINING MOTOR TORQUE



EXAMPLE:

GIVEN: 50 HP., 900 RPM. MOTOR
FIND REQ'D. BRAKE SIZE

T = 300 POUND FEET

USE 13" BUL. 505 BRAKE

NOTE: ALWAYS USE CORRESPONDING SIDES OF H.P. AND
"T" SCALES TO ARRIVE AT CORRECT SOLUTION.

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