SKYAZUL EQUIPMENT SOLUTIONS

Service Training
LMI Systems
Chantilly Va. 2016

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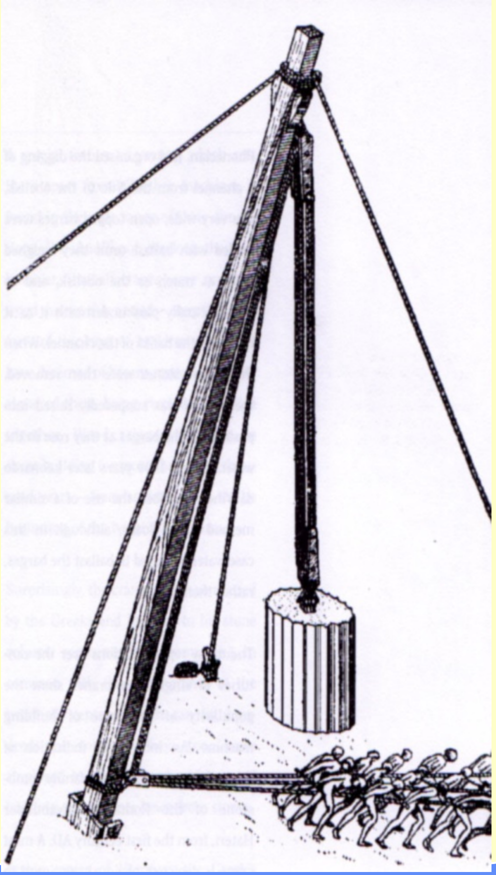
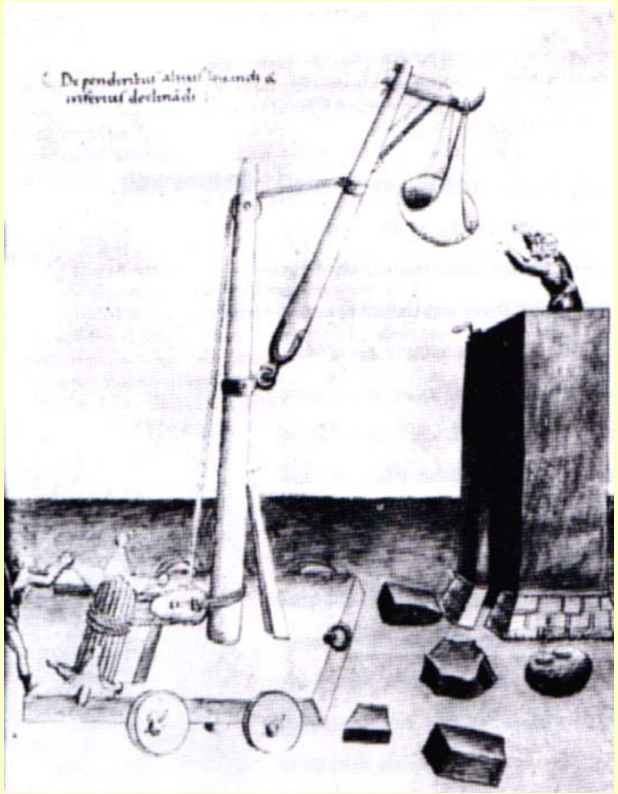
HISTORY

- ☑ Lifting devices have been in use to help mankind for over 5000 years
- ☑ In this single masted roman crane limited slewing was provided by altering the lateral tension in the ropes



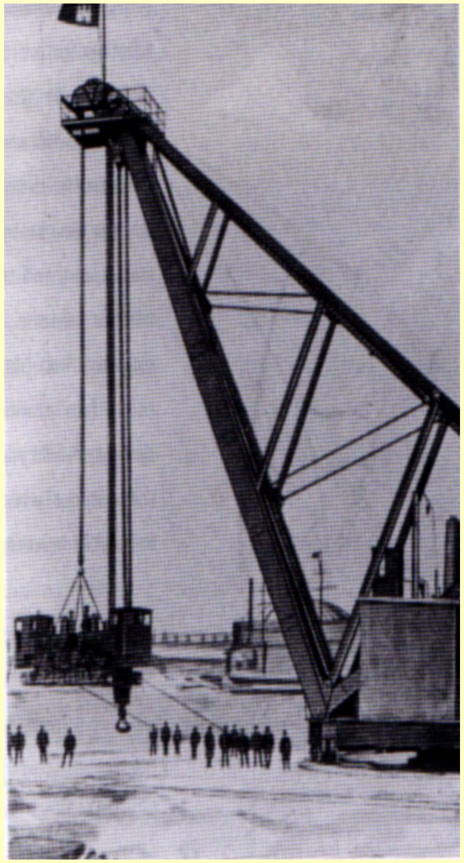
HISTORY

- ☑ By the Middle Ages mobile cranes were developed
- ☑ This sketch is from Italian Engineer Mariano Taccola in 1449



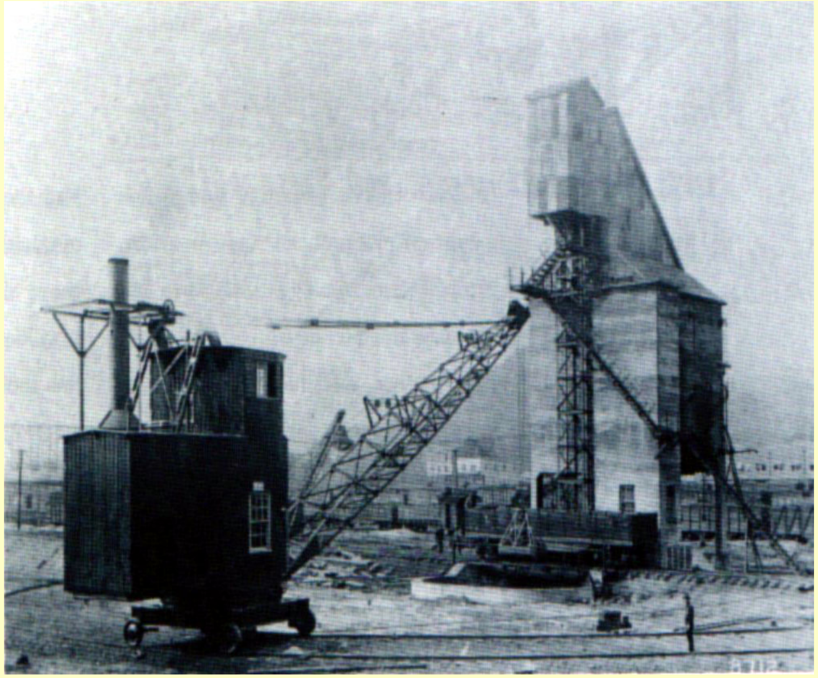
HISTORY

- ☑ In 1885 this Stuckenholz 150 tonne capacity crane was the largest crane in the world
- ☑ This was a slewable harbor crane



HISTORY

- ☑ In 1874 William Ewart received a patent for a chain with interchangeable links.
- ☑ This led to the founding of Link-Belt Machinery Company in 1880
- ☑ In 1890 the first Link-Belt steam crane was built



HISTORY

- ☑ Wreck of a large steam crane which collapsed during jetty construction in Port Talbot UK

HISTORY

- ☑ In 1916 three shareholders of the Manitowoc Shipyard acquired sand and gravel business and contracted with Roy and Charles Moore to build eight “Speedcranes” which led in 1925 to the “Manitowocs”

HISTORY

- ☑ First Patent for an Anti-Two Block device granted by US patent office July 24th 1906
- ☑ Filed by William Baldwin and John Hilder of New York City
- ☑ As employees this patent was assigned to Otis Elevator Company

BEST AVAILABLE COPY

UNITED STATES PATENT OFFICE.

WILLIAM D. BALDWIN, OF NEW YORK, AND JOHN D. IHLDER, OF YONKERS, NEW YORK, ASSIGNORS TO OTIS ELEVATOR COMPANY, OF EAST ORANGE, NEW JERSEY, A CORPORATION OF NEW JERSEY.

AUTOMATIC STOP FOR WHIP-HOISTS.

No. 826,529. Specification of Letters Patent. Patented July 24, 1906.

Application filed March 21, 1904. Serial No. 199,164.

To all whom it may concern:

Be it known that we, WILLIAM D. BALDWIN, residing at New York city, in the county of New York, and JOHN D. IHLDER, residing at Yonkers, in the county of Westchester, State of New York, citizens of the United States, have invented certain new and useful Improvements in Automatic Stops for Whip-Hoists, of which the following is a specification.

Our invention relates to automatic stops for electric whip-hoists; and its object is to prevent such machines from carrying their loads beyond the proper limits of travel and to provide means for avoiding such accidents as might occur from overwinding.

We will describe a whip-hoist comprising our invention and point out the novel features thereof in claims.

Referring to the drawings, Figure 1 is a side elevation of a whip-hoist, showing the mechanical features of the present invention. Fig. 2 is a wiring diagram, showing the electrical connections of a whip-hoist embodying our invention. Fig. 3 is a diagram of a part of the apparatus shown in Fig. 2, but with its circuits somewhat changed to show a modification of the invention.

Like figures of reference indicate corresponding parts in the various figures.

50 designates an electric motor, to the shaft of which is securely attached a friction-pinion 51. This pinion is adapted to coact with a friction-sheave 52. A winding-drum or windlass is attached to a shaft 54, to which the friction-sheave 52 is also attached. The shaft 54 is supported on an eccentric 55, which may be turned by means of a lever 56 to raise or lower the friction-wheel 52. The outer periphery of the friction-wheel 52 is smooth and is adapted when raised to come in contact with a brake-strap 59. The inside of the rim of the friction-wheel 52 is provided with friction-surfaces which are adapted when the sheave is lowered to coact with the friction-pinion 51, so that the sheave 52, and consequently the drum 53, will be driven by the pinion when the latter is rotating. The lever 56 may be operated directly by hand or may be operated from a distance by means of a rope 58 connected to it. A weight 57 may be attached to the lever 56 to facilitate the operation of the apparatus.

20 designates a starting-controller for the motor. It is of a well-known type. It comprises a hand-lever 21, which is connected to one of the mains from a source of electrical supply, in this case the positive main, which is designated by + in the drawings. This hand-lever is held in the position shown against a stop 26 by means of a spring 25. When it is desired to start the motor, the hand-lever 21 is moved to the right. It then establishes a circuit through the contacts 22, the resistance-coils 23, the series field 11, and the armature 10 of the motor to the negative main. The shunt-field 12 of the motor, as here shown, is connected directly across the mains. As the hand-lever 21 is moved farther to the right it cuts out the starting resistance 23 step by step until it reaches the last contact 22, when it is all cut out. The hand-lever also establishes another circuit through a holding-magnet 24, the coil of an auxiliary magnet 30, a limit-switch 40 to the negative main. While an electric current flows through this circuit it energizes the two magnets in it. The first of these (the holding-magnet 24) holds the lever 21 over to the right against the action of the spring 25. The auxiliary magnet 30 separates its contacts 32 33 and breaks what would otherwise be a short circuit across the motor-armature through a resistance 60. This short circuit is shown in the drawings by a broken line made up of dots and dashes. After the motor has been started, as has just been described, it will continue to rotate as long as its circuits are not interrupted. This will impart motion to the friction-pinion 51, and the apparatus may be used for raising and lowering packages at will.

The rope or cable 46, which is used to connect packages to the drum 53, is provided with a stop-ball 47 near its end. This rope is run through or near an arm 44 of the limit-switch 40 and is so arranged that it passes the arm 44 freely, but that the stop-ball 47 will engage the arm 44 and raise the latter if it runs against it. The arm 44 is pivoted at 45. The other end 43 forms the movable blade of an electric switch and normally

HISTORY

- ☑ The first patent application for a safe load indicator was filed in Great Britain December 1930 by Archibald Frazer Nash
- ☑ US Patent issued February 11th, 1936

Patented Feb. 11, 1936 — 2,030,529

UNITED STATES PATENT OFFICE

2,030,529

SAFETY DEVICE FOR CRANES AND THE LIKE

Archibald Fraser Nash, Kingston Hill, England

Application December 22, 1931, Serial No. 582,666
In Great Britain December 29, 1930

3 Claims. (Cl. 116—114)

This invention relates to lifting devices and particularly to cranes, derricks, shear legs and the like lifting devices provided with luffing gear or otherwise with means adapted to provide a varying radius of lift and has for its object to provide improved means adapted to operate to ensure that the limits of safety of the device will not be exceeded as, for instance, by giving a visible, audible or other warning signal to the operator of the device with or without simultaneously actuating means for positively deferring or interrupting the operation of the lifting device when the safe load is exceeded.

According to the invention the safety means comprises two independently moving elements, one actuated by the magnitude of the load to be raised, the other actuated in accordance with the angle of inclination of the jib or its equivalent or otherwise in accordance with variations in the radius of lift, said elements being associated one with the other in such manner that the relation between the positions they are caused to assume will operate to indicate when the lifting device is overloaded and/or to indicate the relation between the magnitude of the load and the permissible limit of loading.

At this point it may be mentioned that the invention extends not only to cranes provided with jibs or the like, the inclination of which is adapted to be varied, but also to hammer-head and shipyard cranes and other lifting devices in which, for instance, the crane hook or its equivalent is arranged on a carriage adapted to travel on a cantilever or a similar structure.

Thus in accordance with the invention, an indicator adapted to be moved relatively to a scale in accordance with the angle of inclination of the jib or its equivalent or otherwise in accordance with variations in the radius of lift and which may directly indicate the magnitude of the angle is associated with a second indicator actuated solely or principally by the weight of the load being raised in such manner that the two indicators will cooperate in showing when the safe load is exceeded.

For instance, an indicator adapted to be moved in accordance with the variation of the angle of inclination of the jib or otherwise in accordance with variation in the radius of lift may be provided with an index cooperating with a scale and adjacent thereto and cooperating with the index there may be arranged a second indicator adapted to be influenced by the magnitude of the load in such manner as to cause a second scale, with divisions marked "Safe", "Maximum", and "Danger" to be moved relatively to the main scale and to the index.

Alternatively, the indicator adapted to be moved in accordance with the variation in the radius of lift may be provided with an index plate or scale having divisions marked "Safe", "Maximum" and "Danger" and with this indicator there may be associated a scale marked with divisions adapted to indicate the magnitude of the load being raised and adjacent to the first-mentioned indicator there may be arranged to cooperate with the scale a second indicator adapted to be moved over the scale in accordance with the magnitude of the load.

The invention will be described further in detail and by way of example with reference to the accompanying drawings, in which:—

Figure 1 is a view of one construction,

Figure 2 being a view of a detail thereof;

Figures 3, 4, 5, 6, 7, and 8 are fragmentary views illustrating various alternative means whereby the effect of the load on the burden rope or chain may be applied to a device for indicating the magnitude of the load such, for instance, as is illustrated in Figures 1 and 2;

Figure 9 illustrates an alternative construction in which the effect of the load is applied through the jib to hydraulic balancing means,

Figures 10, 11, and 12 illustrate alternative hydraulic balancing means which may be employed;

Figures 13, 14, 15, and 16 illustrate further arrangements in which the effect of the load is applied to the base of the jib;

Figure 17 illustrates one application of the invention to a derrick;

Figure 18 is a view in elevation and partly in section of another construction adapted more particularly for application to luffing cranes;

Figure 19 is a view in front elevation showing the indicator dial thereof;

Figure 20 is a dissected view in elevation showing certain elements of the construction illustrated in the preceding figures;

Figure 21 is a corresponding plan view;

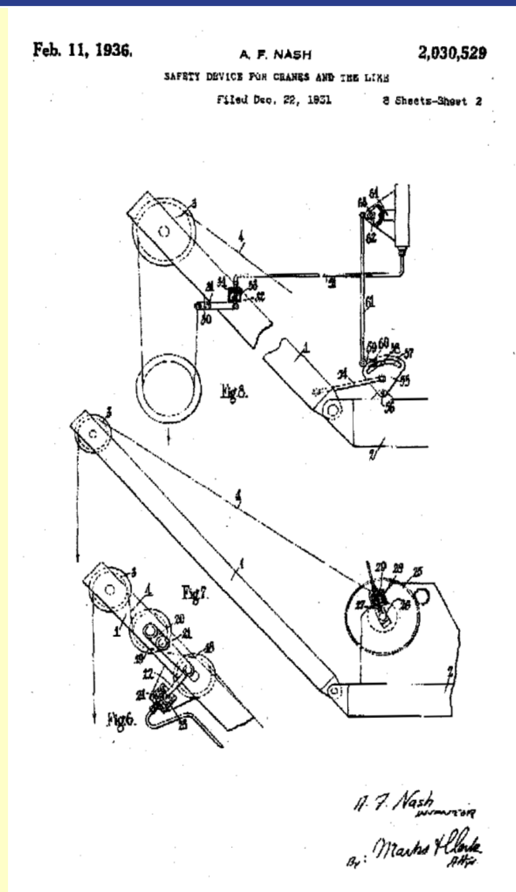
Figure 22 is a view of certain other details which in Figure 18 are superimposed on the details shown in Figure 20,

Figure 23 being a plan view corresponding with Figure 22,

Figures 24, 25, and 26 illustrate three further constructions of jib crane in accordance with the invention, and

Figures 27 and 28 are, respectively, a view in side elevation and a fragmentary view partly in

HISTORY


Feb. 11, 1936.
A. F. NASH
2,030,529
SAFETY DEVICE FOR CRANES AND THE LIKE
Filed Dec. 22, 1931
8 Sheets-Sheet 2
Fig.8.
Fig.7.
Fig.6.

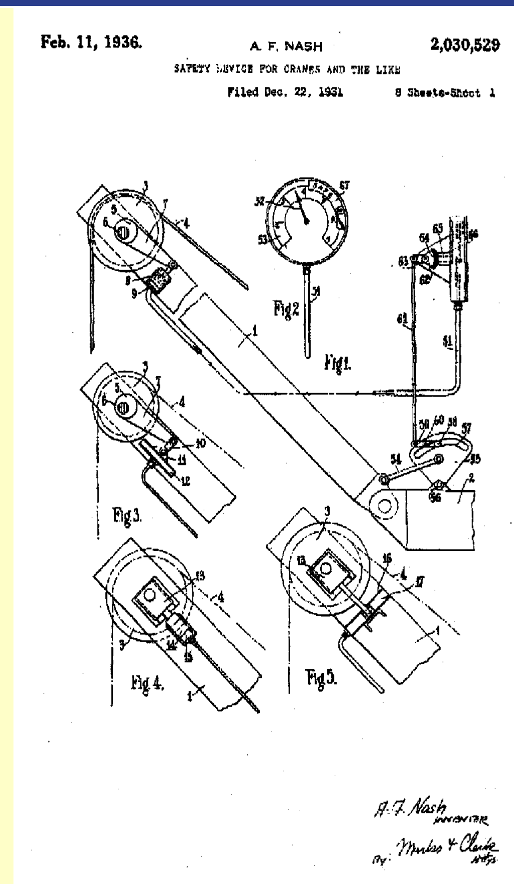

Feb. 11, 1936.
A. F. NASH
2,030,529
SAFETY DEVICE FOR CRANES AND THE LIKE
Filed Dec. 22, 1931
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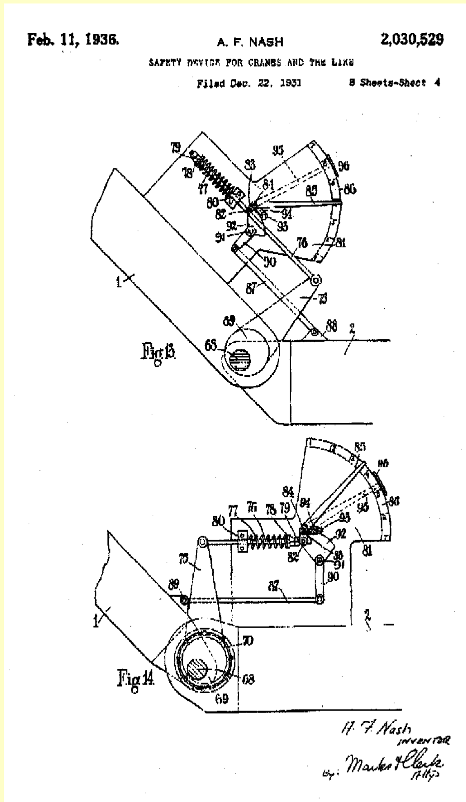
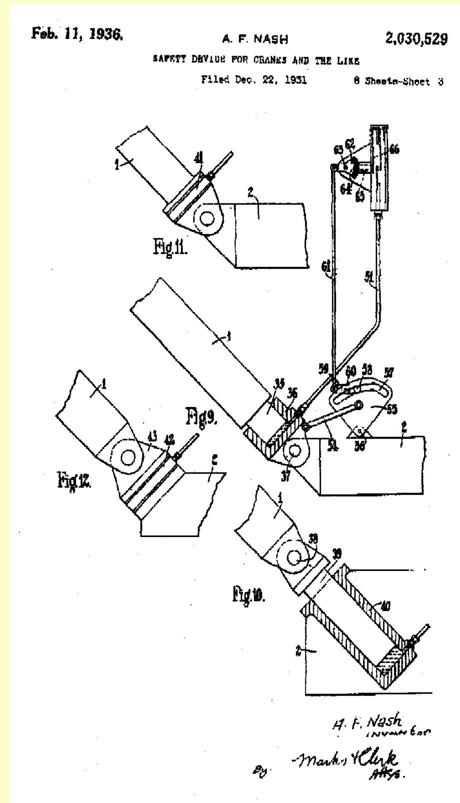
Fig.2
Fig.1.
Fig.3.
Fig.4.
Fig.5.

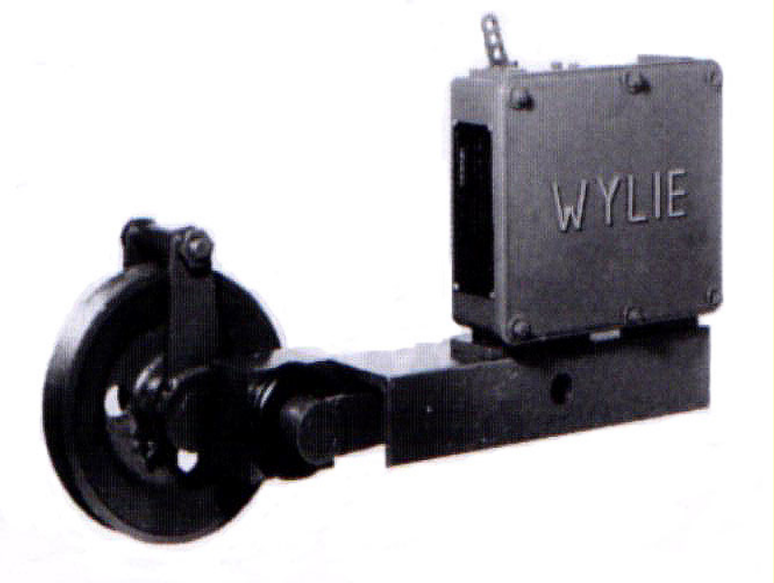
HISTORY


Feb. 11, 1936.
A. F. NASH
2,030,529
SAFETY DEVICE FOR CRANES AND THE LIKE
Filed Dec. 22, 1931
8 Sheets-Sheet 4
Fig 13.
Fig 14.
A. F. Nash
INVENTOR
By: Marks & Clerk
Attys


Feb. 11, 1936.
A. F. NASH
2,030,529
SAFETY DEVICE FOR CRANES AND THE LIKE
Filed Dec. 22, 1931
8 Sheets-Sheet 3
Fig.11.
Fig.9.
Fig.12.
Fig.10.
A. F. Nash
INVENTOR
By: Marks & Clerk
Attys.

HISTORY

- ☑ March 1932 the first factory Inspectorate Approval Certificate in the UK mandated the use of safety devices for crane
- ☑ 1934 B&A Engineering acquires Wylie Safe Load Indicators Inc.
- ☑ 1934 Krueger Systems founded in Germany

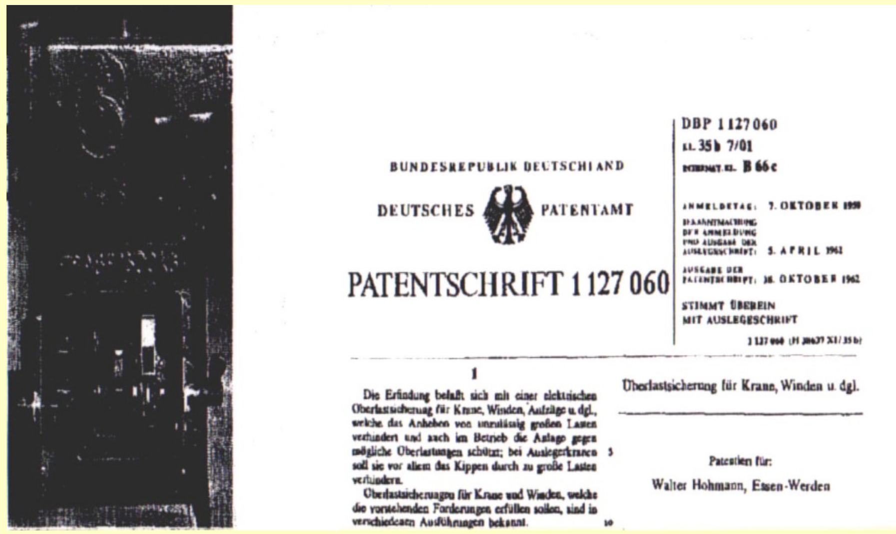


HISTORY

- ☑ MAN rail mounted crane built in Germany was the first to include a “Load Moment Safety Device” as standard equipment in 1946

HISTORY

- ☑ 1957 German Patent for electronic overload safety device by Walter Hohman of Krueger Systems



BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENTAMT

PATENTSCHRIFT 1 127 060

DBP 1 127 060

KL. 35 b 7/01

INTERNAT. KL. B 66 c

ANMELDETAG: 7. OKTOBER 19[illegible]

BEKANNTMACHUNG DER ANMELDUNG UND AUSGABE DER AUSLEGESCHRIFT: 5. APRIL 1961

AUSGABE DER PATENTSCHRIFT: 18. OKTOBER 1962

STIMMT ÜBEREIN MIT AUSLEGESCHRIFT

1 127 060 (H [illegible] XI/35 b)

Überlastsicherung für Krane, Winden u. dgl.

Patentiert für:

Walter Hohmann, Essen-Werden

1

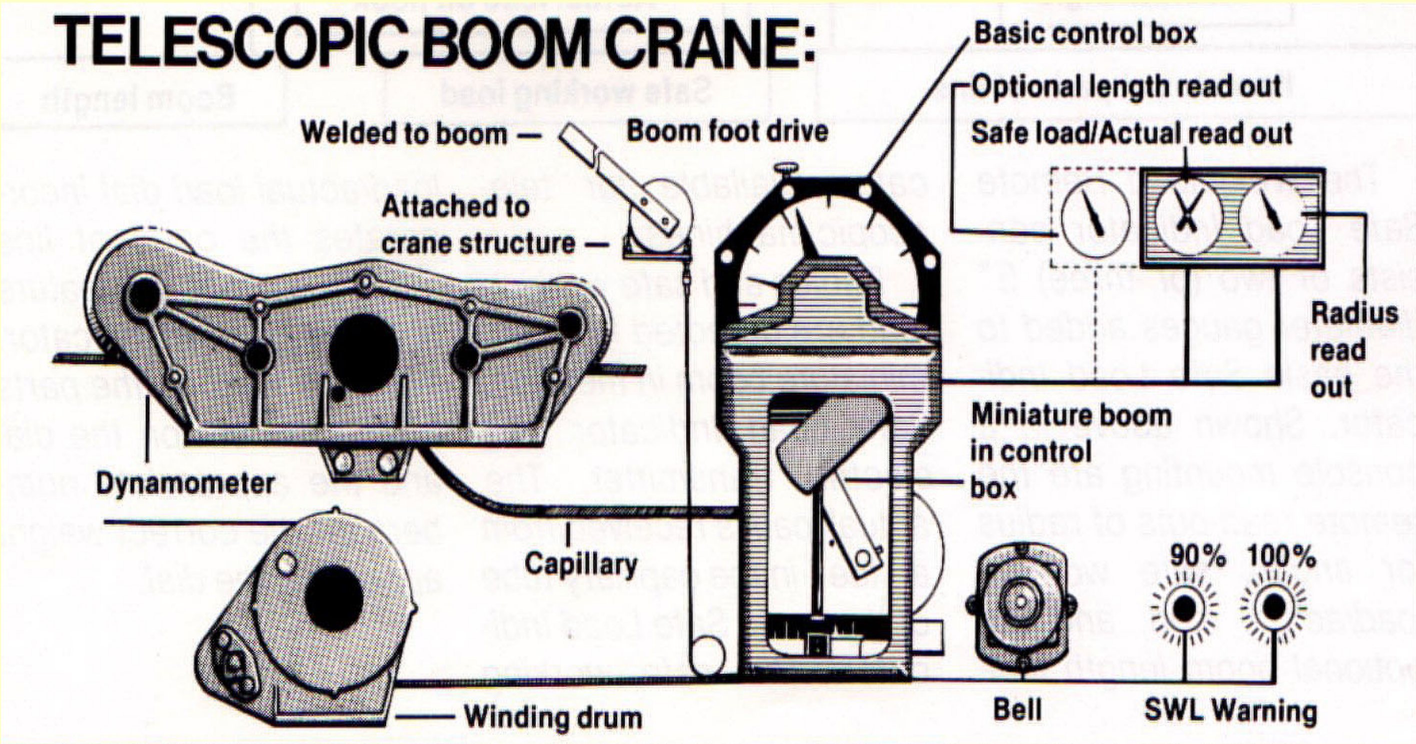
Die Erfindung befaßt sich mit einer elektrischen Überlastsicherung für Krane, Winden, Aufzüge u. dgl., welche das Anheben von unzulässig großen Lasten verhindert und auch im Betrieb die Anlage gegen mögliche Überlastungen schützt; bei Auslegerkranen soll sie vor allem das Kippen durch zu große Lasten verhindern.

Überlastsicherungen für Krane und Winden, welche die vorstehenden Forderungen erfüllen sollen, sind in verschiedenen Ausführungen bekannt.

HISTORY

- ☑ Weighload founded in the UK in 1963 by Brian Gene Nixon
- ☑ Weighload used a load line measuring system which minimized calibration

HISTORY


TELESCOPIC BOOM CRANE:
Welded to boom
Boom foot drive
Attached to crane structure
Basic control box
Optional length read out
Safe load/Actual read out
Radius read out
Miniature boom in control box
Dynamometer
Capillary
90%
100%
Bell
SWL Warning
Winding drum

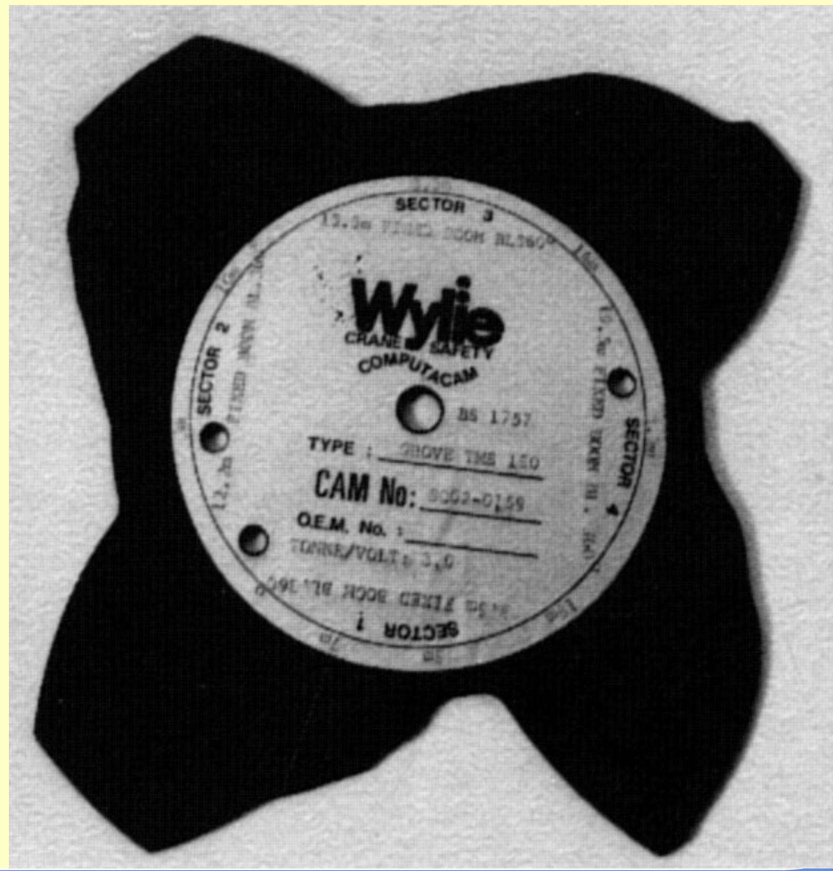
SKYAZUL EQUIPMENT SOLUTIONS

HISTORY

- ☑ Weighload installation on a Grove Crane

HISTORY

- ☑ Mechanical Safe Load Indicators utilized a precut cam that characterized the crane capacity

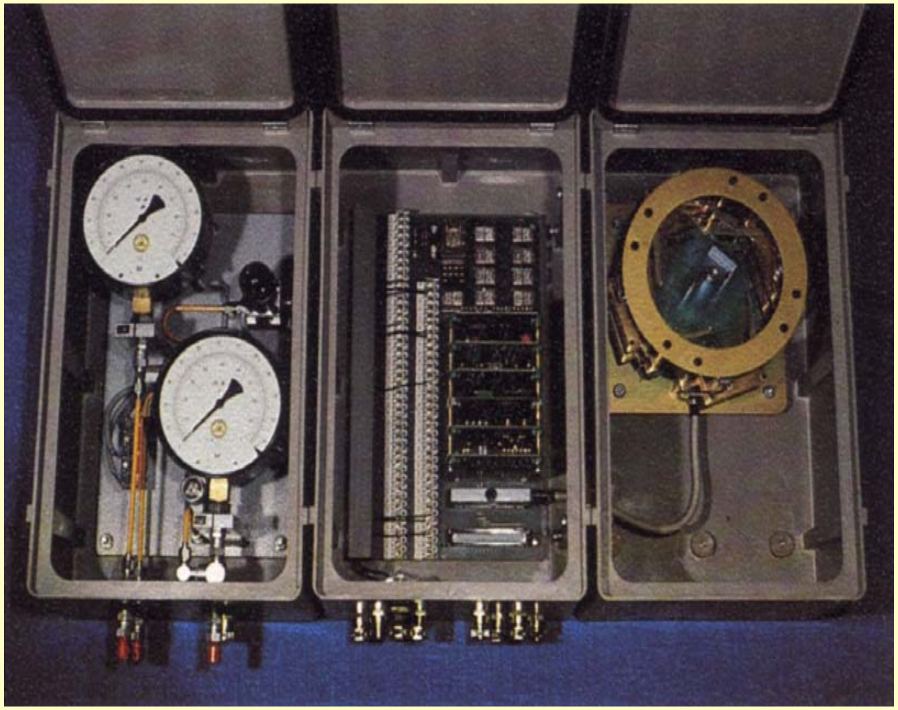


HISTORY

- ☑ EKCO INSTRUMENTS LIMITED introduces the first all electronic SLI in 1969

HISTORY

- ☑ 1968 PAT founded in Germany by Dr. Ludwig Pietzsch
- ☑ 1969 Krueger introduces Mark I electromechanical safe load indicator

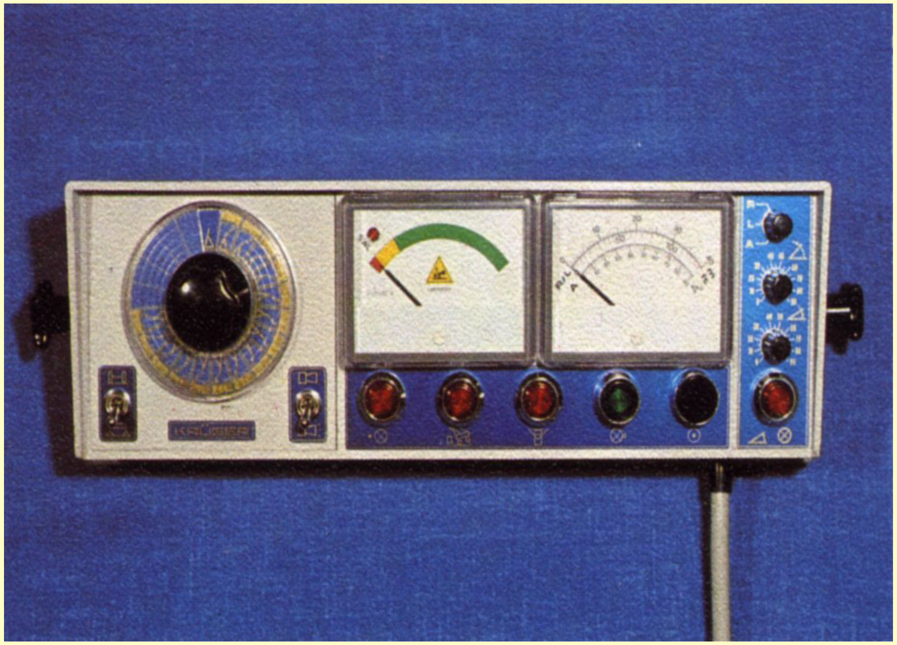


HISTORY

- ☑ 1969 Markload Systems Inc. established in Pearland Texas
- ☑ Gerald L Greer Co. established in Fountain Valley, California

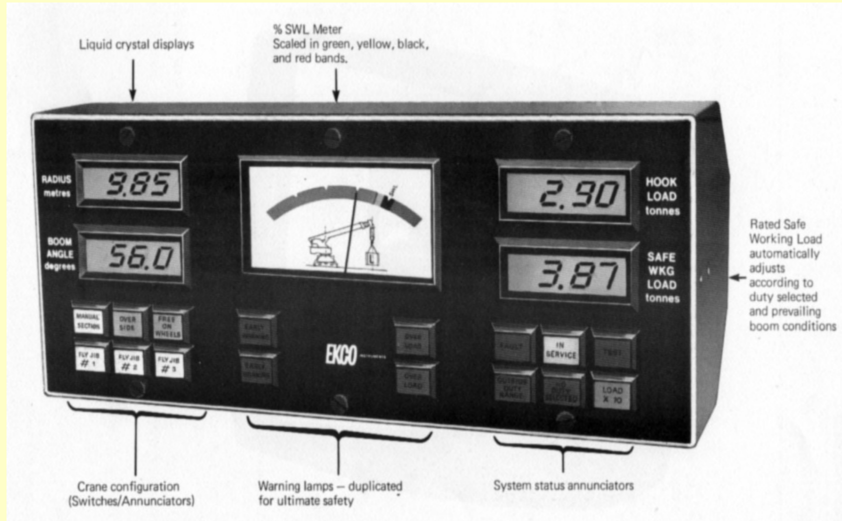
HISTORY

- ☑ 1976 Krueger Systems introduces Mark II



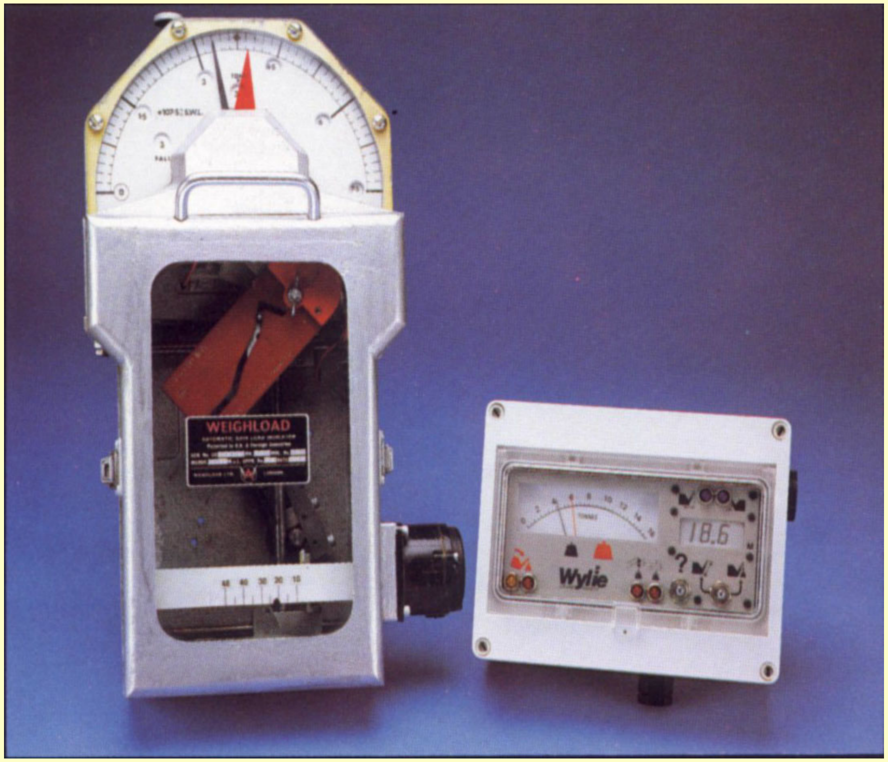
HISTORY

- ☑ 1976 ECKO Introduces first microprocessor based SLI “Microguard”



HISTORY

- ☑ B&A Engineering purchased Weighload in 1984 and offered both the Wylie and Weighload systems.
- ☑ Weighload office in Alliance OH was moved to Wylie office in Tulsa Oklahoma
- ☑ 1984 Former Weighload employees started Load Instrumentation Inc.



PAT Historical Timeline

1968 – Peitzsch AG was founded in Germany by Dr. Peitzsch. The systems were based on Strain gage technology.

1970 – The first PAT SLI (Safe Load Indicator) was introduced. The AS-110 analog system.

1978 – PAT America was incorporated. Operations were set up in Boston, Massachusetts.

1987 – PAT received a contract from Grove Crane for machines greater than 50 ton capacity. Due to the increase in business, PAT opened a location in Waynesboro, PA.

1989 – PAT introduced the DS 350 G system as a standard on all GROVE cranes.

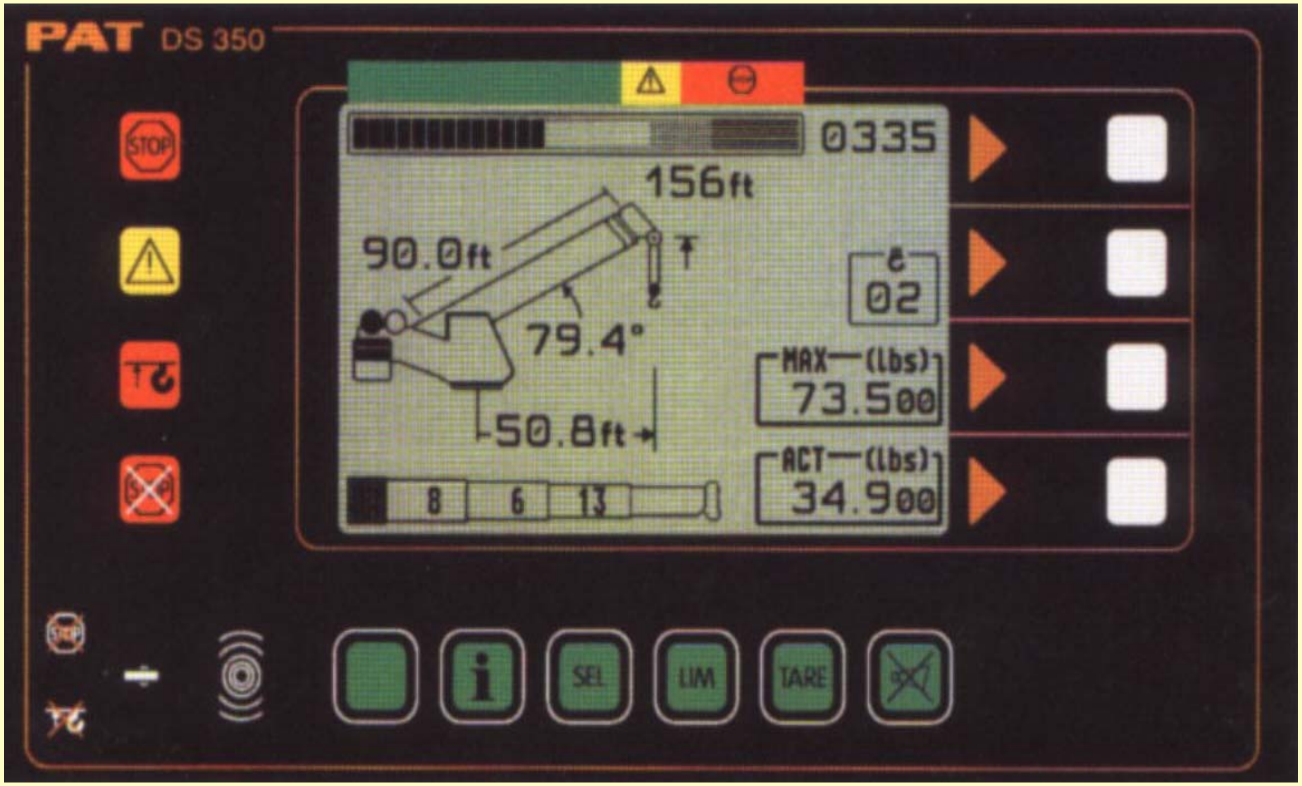
1996 – PAT introduces DS 350M Modular Graphic LMI System

1996 – PAT continues its growth by acquiring Kruger Systems LP.

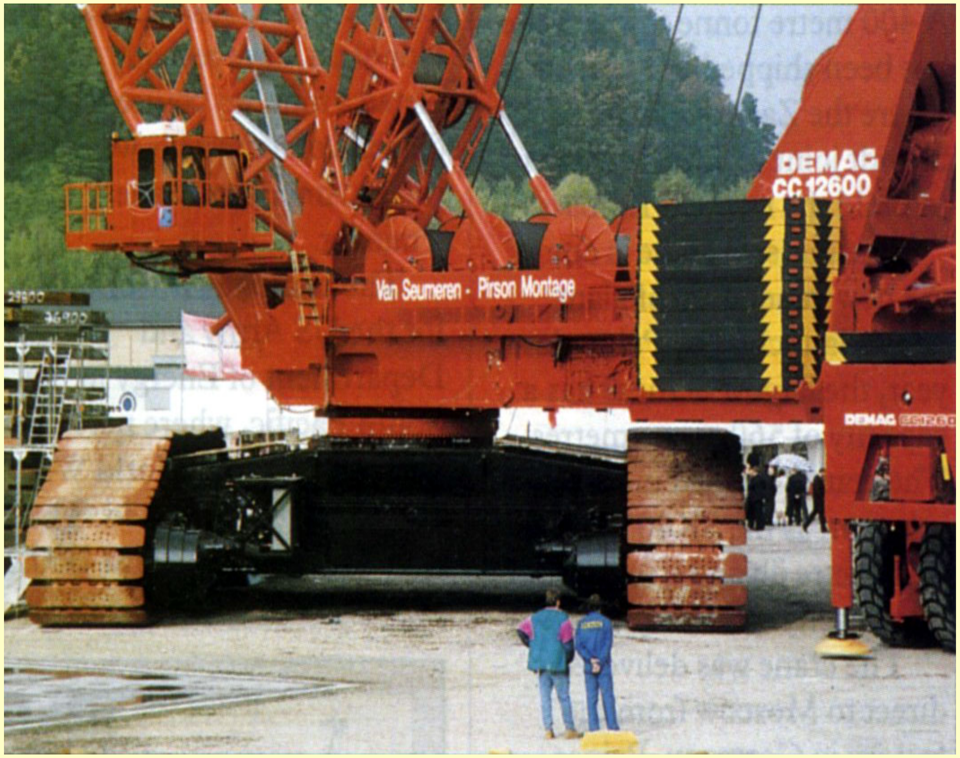
2001 – PAT acquires Compu-Crane.

2002 – Introduced the iFlex5 system, PRS 75 systems, and Motion Alert system at Con-Expo.

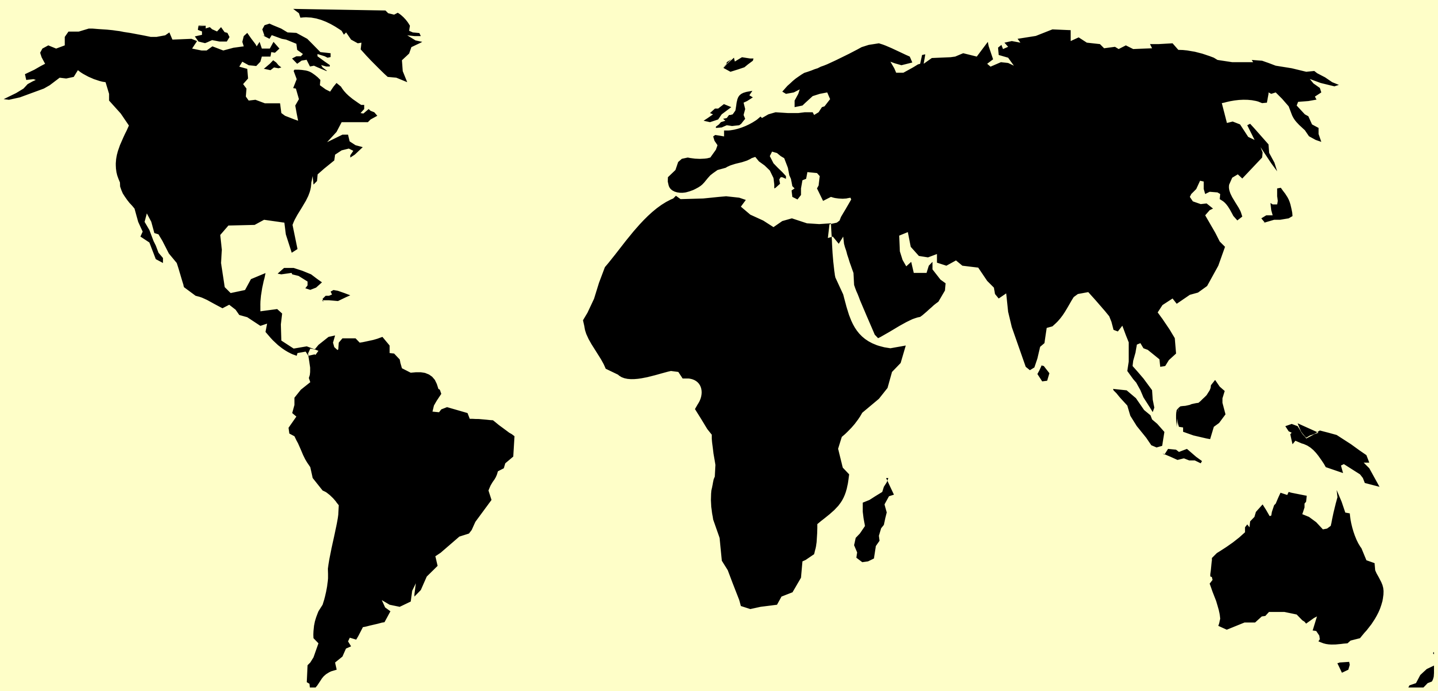
Systems Today - Grove



Systems Today - Demag



Standards

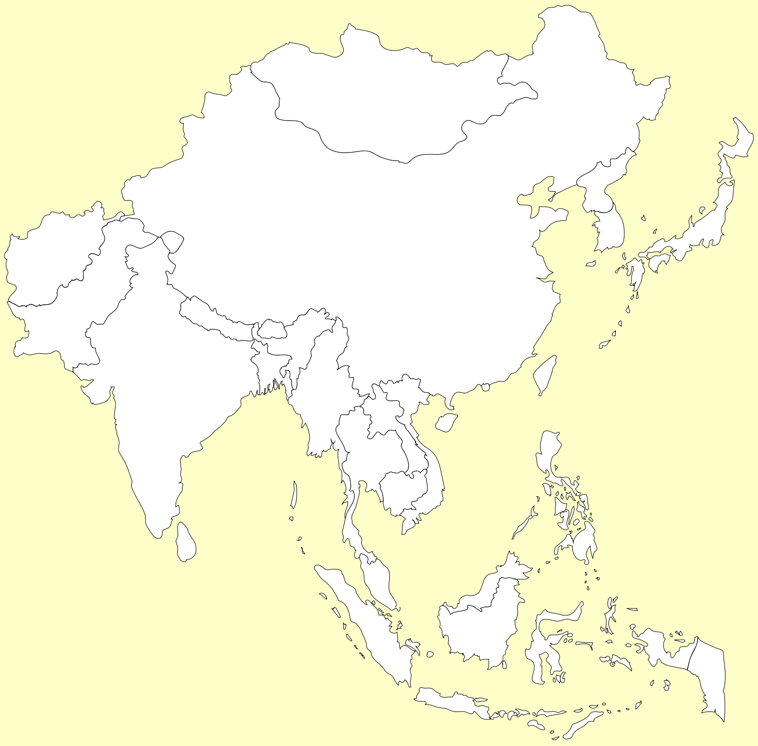


Standards - Latin America

- ☑ Venezuela and Chile have adopted the ANSI B-30.5 Standard from the US
- ☑ PEMEX in Mexico has required SLI's on all purchases and contracts
- ☑ European and U.S. oil companies operating in Columbia and Ecuador requires SLI systems

Standards - Pacific Rim

- ☑ SLI's are compulsory in Japan and Hong Kong
- ☑ Singapore require SLI's on mobile cranes
- ☑ Malaysia requires SLI's on Luffing Tower Cranes
- ☑ Australia and New Zealand require SLI's on all cranes above 3 tonnes capacity



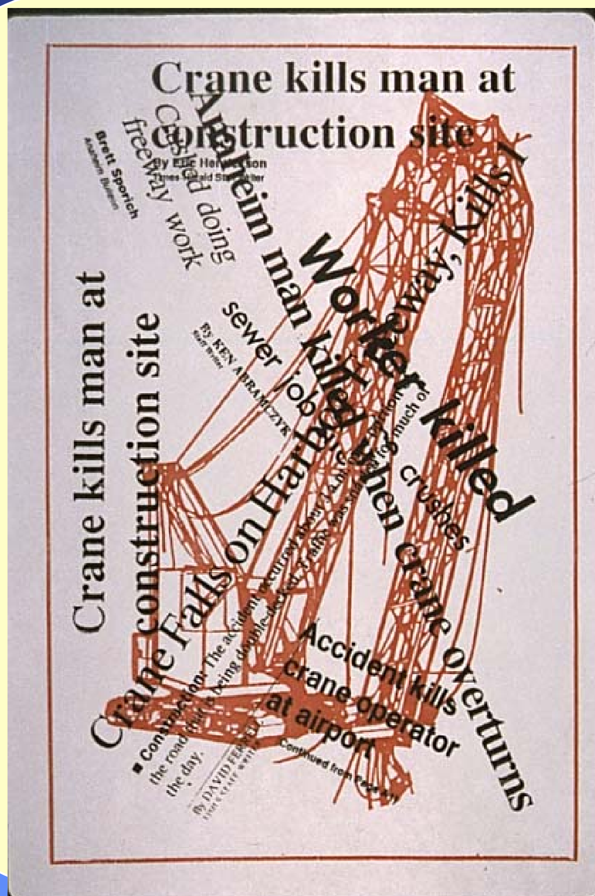
Standards - Europe

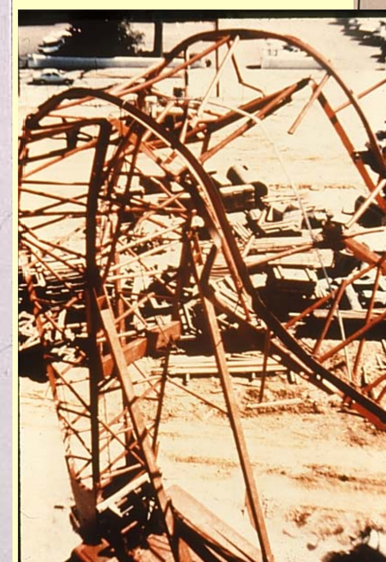
- ☑ UK first mandated SLI's in 1934
- ☑ Central Europe requirements since 1968
- ☑ Most strict in Holland
- ☑ Spain requires load and angle indication
- ☑ CEN requirements to standardize all of Europe
- ☑ European standards allow calibration at 100% - capacities based on 66% or 75%

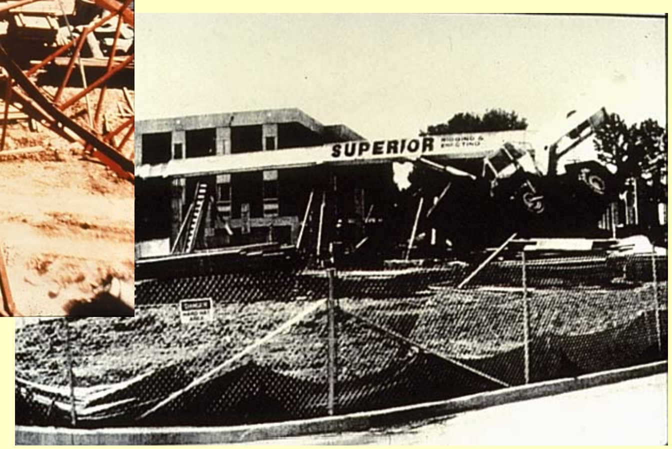
Standards - North America

- ☑ United States OSHA adopted SLI requirement in 1971 but was repealed 3 months later after pressure from HSSC and CIMA
- ☑ Current B-30.5 has been revised to require Load Indicators or RCI on all cranes 3 ton and above
- ☑ Canadian Z-150 regulation has been revised to include Load Indication
- ☑ OSHA has updated the standard to reference the Current B.30.5 since 2010

Crane Safety

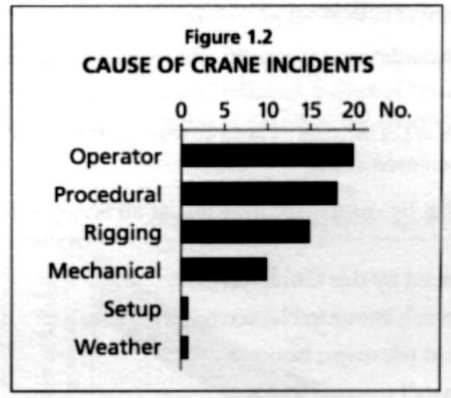


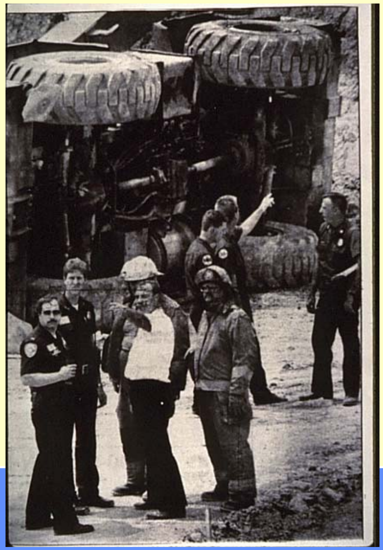


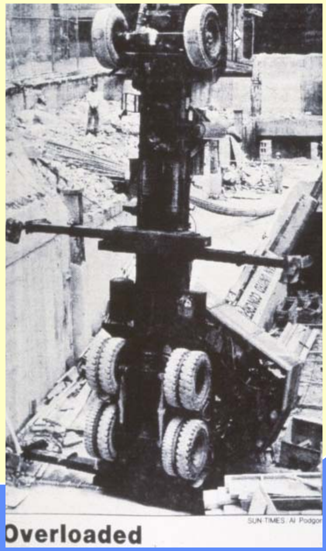


Crane Safety

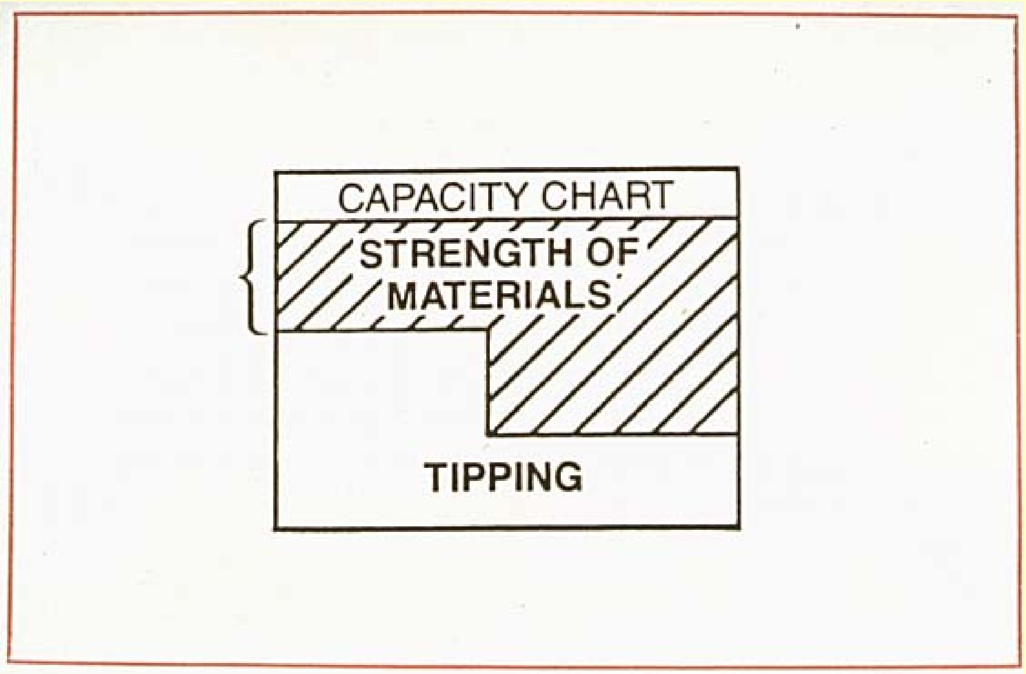
- ☑ Crane Manufacturers in the United States recognized the benefits of SLI's in the 1980's and by 1989 Grove Standardized with the PAT DS-350 LMI system
- ☑ In 1990 Link-Belt and Lorain made the Greer LMI System standard
- ☑ P&H Century II Standardized in 1992 with Krueger and PAT







Crane Design



Crane Design

- ☑ Cranes are being designed with high tensile steel for stronger ,lighter, more roadable machines
- ☑ Boom deflection has a greater impact
- ☑ The structural portion of the load chart is expanded
- ☑ The operator can no longer operate from the “seat of his pants”

RATED LIFTING CAPACITIES IN POUNDS WITH 18,000 LB. COUNTERWEIGHT
36 FT. - 110 FT. BOOM

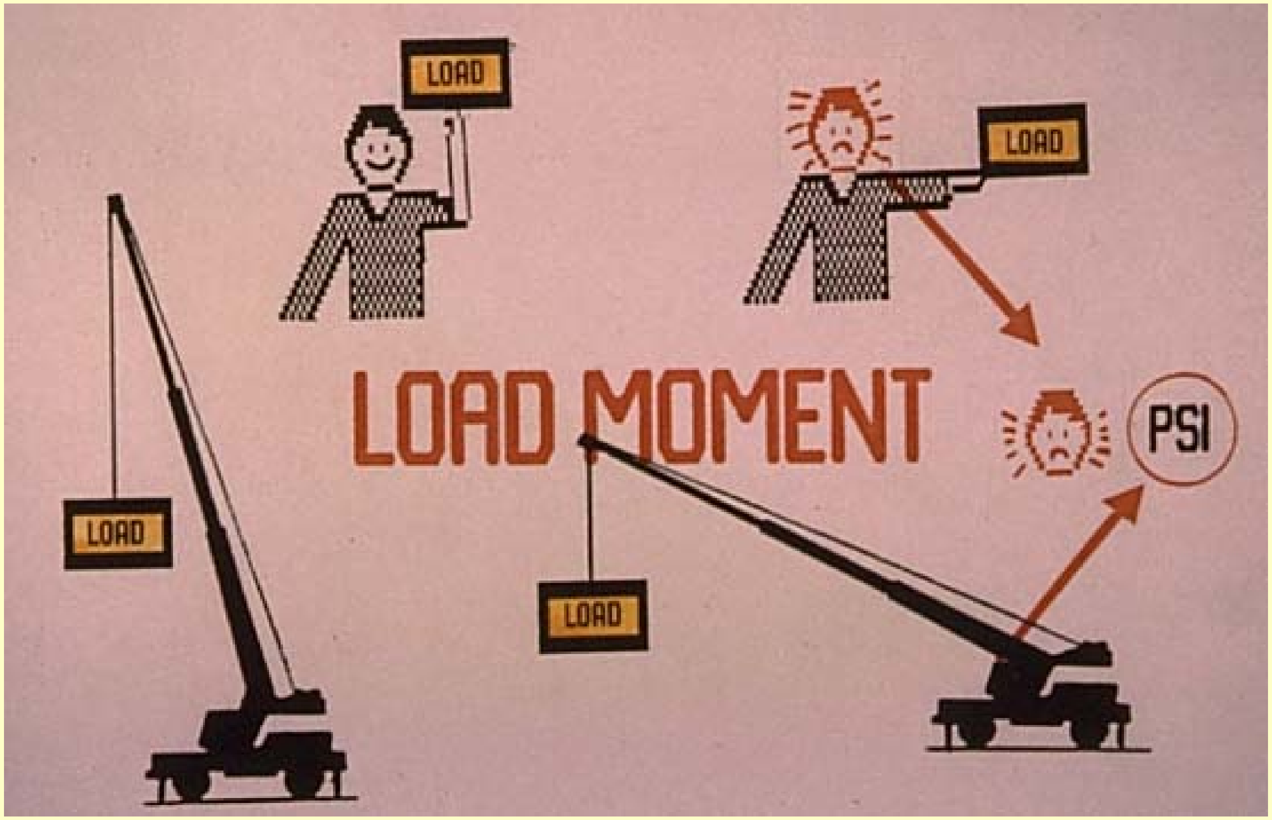
ON OUTRIGGERS FULLY EXTENDED - 360°

Radius in Feet	#0501 Main Boom Length in Feet							
	36	50	*60	70	80	90	100	110
10	140,000+ (68)	109,500 (75)	84,200 (78)	**56,450 (80)				
12	110,500 (64)	104,500 (72.5)	79,850 (76)	56,450 (78.5)				
15	96,800 (58.5)	91,400 (69)	73,900 (73)	56,450 (76)	56,500 (78.5)	**47,850 (80)		
20	78,750 (47)	75,300 (62)	59,600 (67.5)	56,450 (71.5)	50,950 (74.5)	41,000 (77)	40,350 (79)	**27,350 (80)
25	59,800 (32.5)	59,750 (55)	50,000 (62.5)	48,900 (67)	43,800 (71)	35,250 (73.5)	34,750 (76)	27,350 (78.5)
30		47,300 (47)	42,300 (56.5)	41,900 (62.5)	38,300 (67)	31,050 (70.5)	30,450 (73)	27,350 (75.5)
35		38,550 (37.5)	36,950 (50)	36,400 (57.5)	33,900 (63)	27,650 (67)	27,000 (70)	25,300 (72.5)
40		28,450 (24.5)	28,450 (43)	29,700 (52)	30,300 (58.5)	24,350 (63)	24,250 (67)	22,900 (70)
45			23,400 (34.5)	24,650 (46.5)	25,550 (54)	22,050 (59.5)	21,900 (63.5)	20,850 (67)
50	See Note 16		19,450 (23)	20,700 (39.5)	21,600 (49)	20,050 (55.5)	19,950 (60)	19,100 (64)
55				17,500 (32)	18,450 (43.5)	18,350 (51)	18,300 (56.5)	17,550 (61)
60				14,900 (21)	15,850 (37.5)	16,550 (46.5)	16,850 (53)	16,200 (57.5)
65					13,650 (30)	14,350 (41.5)	14,900 (49)	15,050 (54.5)
70					11,650 (20)	12,500 (35.5)	13,050 (44.5)	13,500 (50.5)
75						10,900 (29)	11,450 (39.5)	11,900 (47)
80						9,480 (19)	10,000 (34.5)	10,500 (43)
85							8,790 (28)	9,260 (38.5)
90							7,690 (18.5)	8,150 (33)
95								7,170 (27)
100								6,280 (18.5)
Minimum boom angle (deg.) for indicated length (no load)								0
Maximum boom length (ft.) at 0 degree boom angle (no load)								110

NOTE: ( ) Boom angles are in degrees.

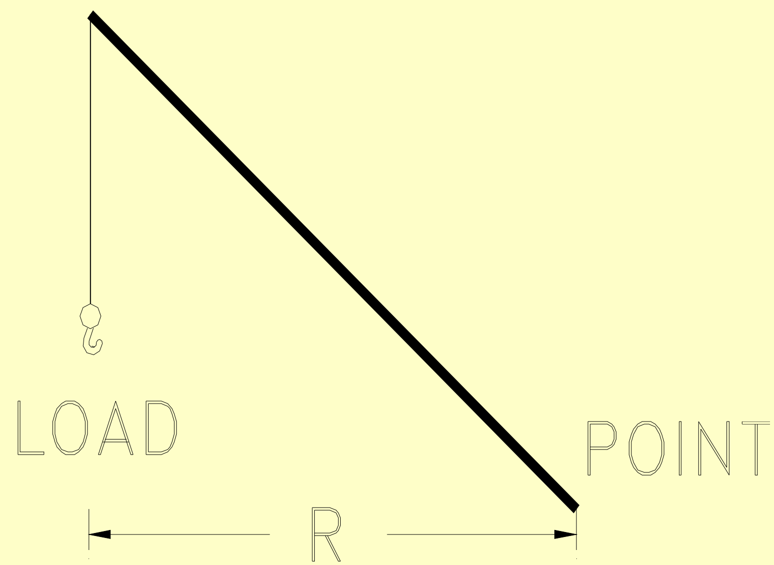
#LMI operating code. Refer to LMI manual for instructions.
**This capacity is based on maximum boom angle.

What is Load Moment?



Load Moment

- **Moment -** the product of a physical quantity and its perpendicular distance from an axis
- For Mobile Cranes Load Moment is a product of the Load and the perpendicular distance between the C.G. of the Load and the Centerline of Rotation of the Crane



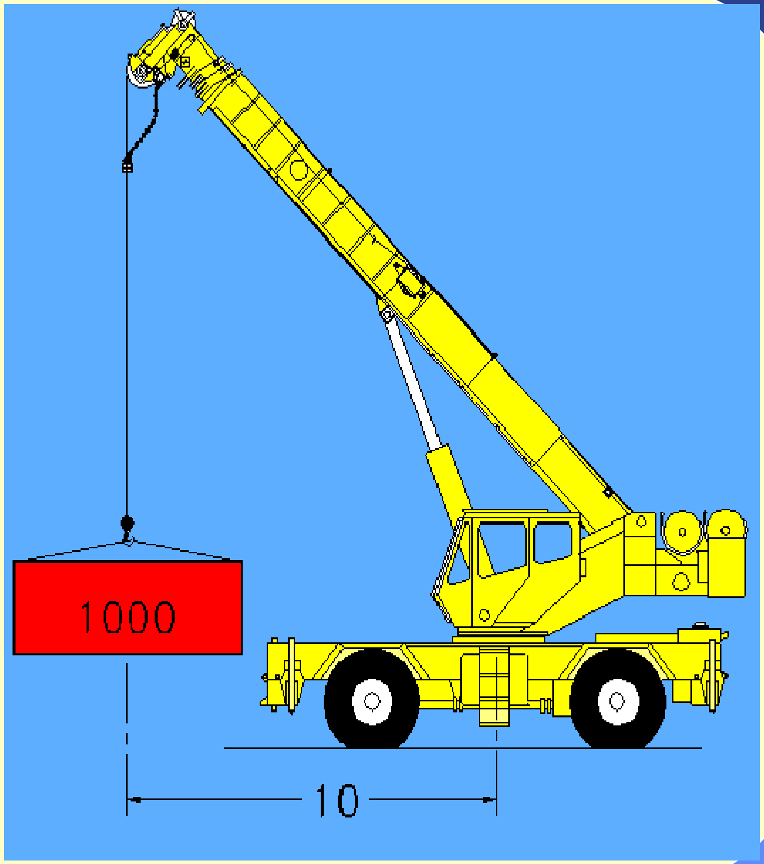
Load Moment

Load = 1,000 Units

Load Radius = 10 Units

Load Moment = 1,000 x 10

= 10,000 Units



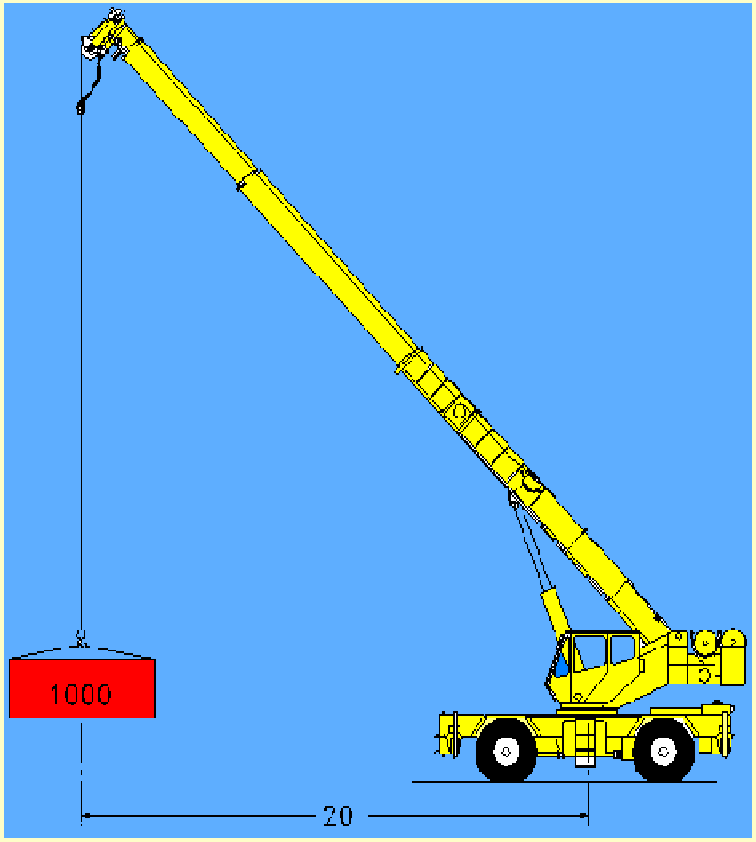
Load Moment

Load = 1,000 Units

Load Radius = 20 Units

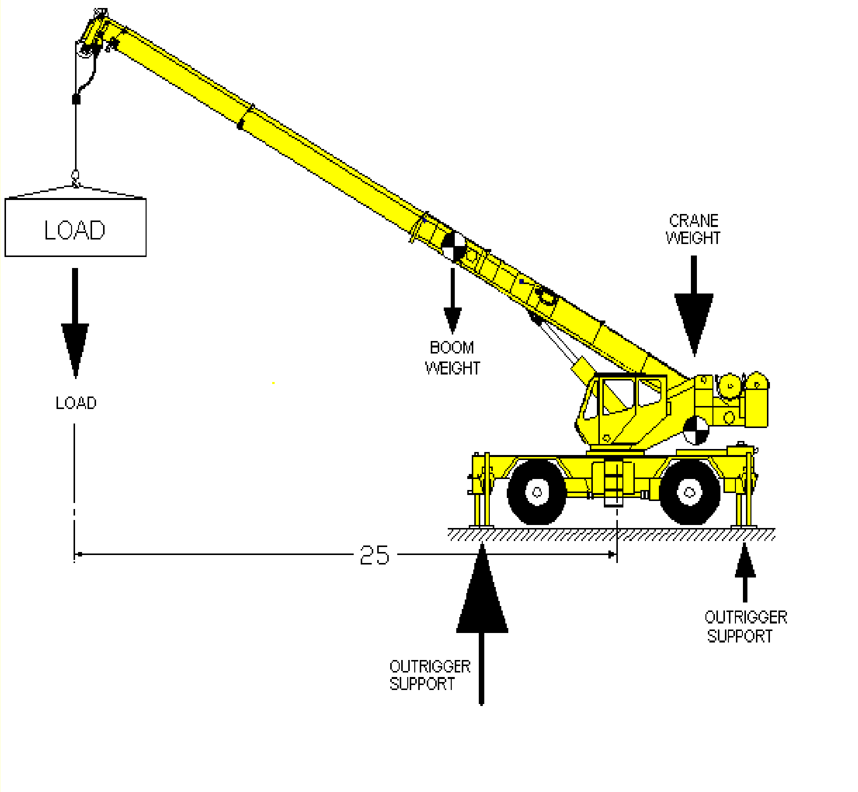
Load Moment =1,000 x 20

= 20,000 Units



Load Moment

- ☑ **Overturning Moment forces acting on a crane include the Load and the weight of the boom**
- ☑ **Stabilizing Moment Forces acting on the Crane include the weight of the crane acting through the center of gravity of the crane**



Load Moment

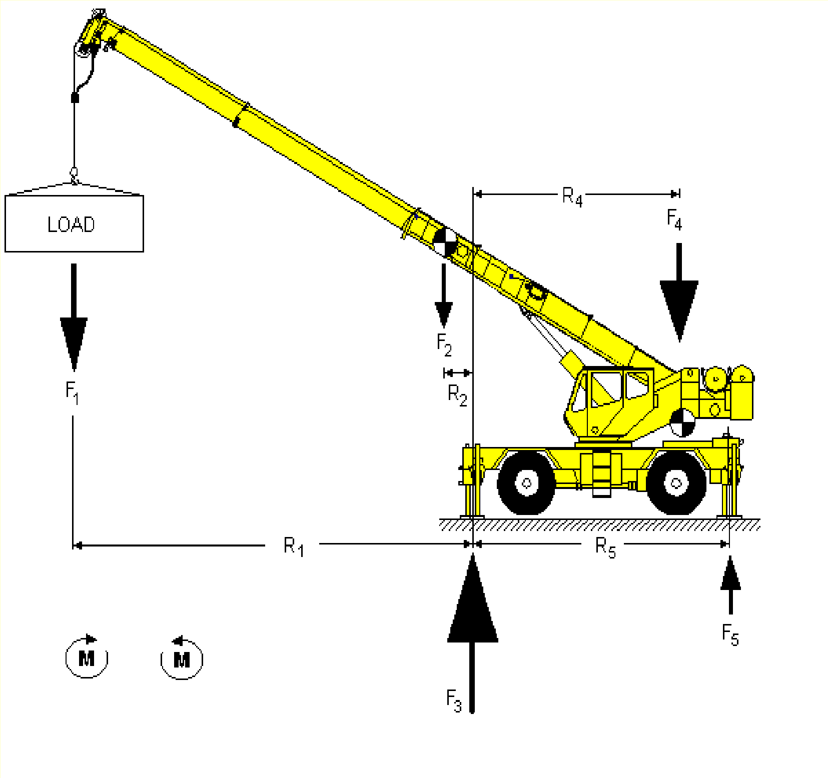
Overturning Moment =

F1 x R1

+ F2 x R2

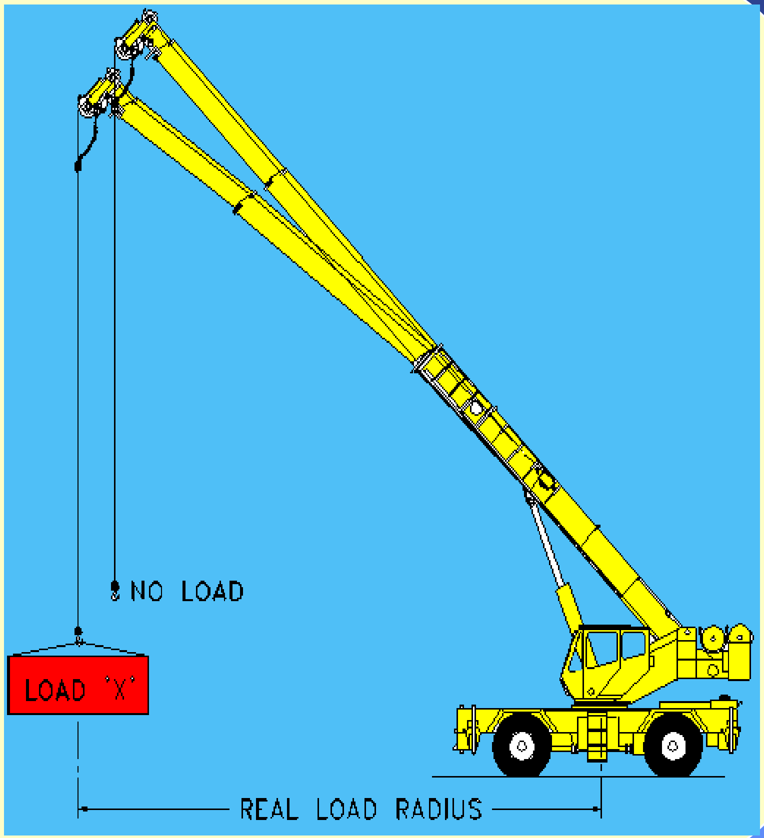
Stabilizing Moment =

F4 x R4



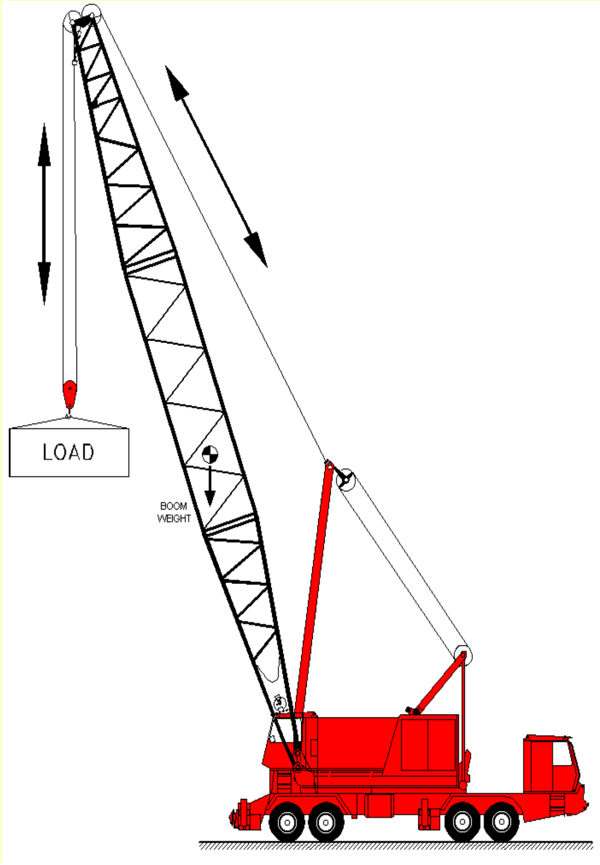
Load Moment

- ☑ Load Moment is equally affected by changes in Load or Radius.
- ☑ Under load; boom and carrier deflection can increase load radius by 15% or more.
- ☑ A 15% increase in radius will result in a 15% increase in Load Moment-



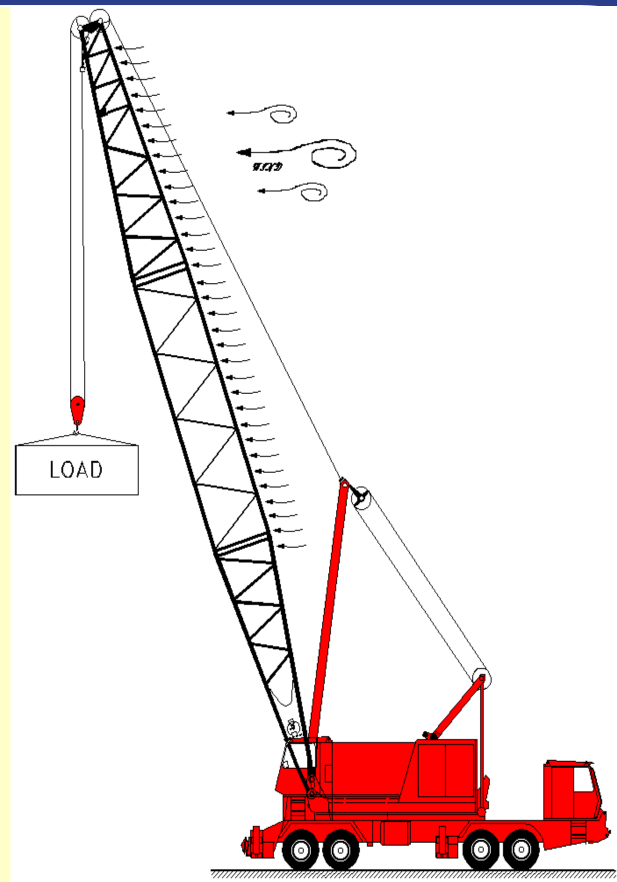
Load Moment

- ☑ For Lattice Boom Cranes the Boom Pendants provide an offsetting force to the load reducing main boom deflection
- ☑ Deflection can be significant for jib configurations



Load Moment

- ☑ Load moment measuring for lattice boom cranes helps monitor additional loads due to icing; wind; shock loads etc.
- ☑ Wind load force is a function of the wind velocity squared. Doubling the wind speed increases the force by a factor of four



System Components

- ☑ A2B System
- ☑ Boom Length Sensor
- ☑ Boom Angle Sensor
- ☑ Piston side pressure transducer
- ☑ Rod side pressure transducer
- ☑ Central Processing Unit
- ☑ Operators Console