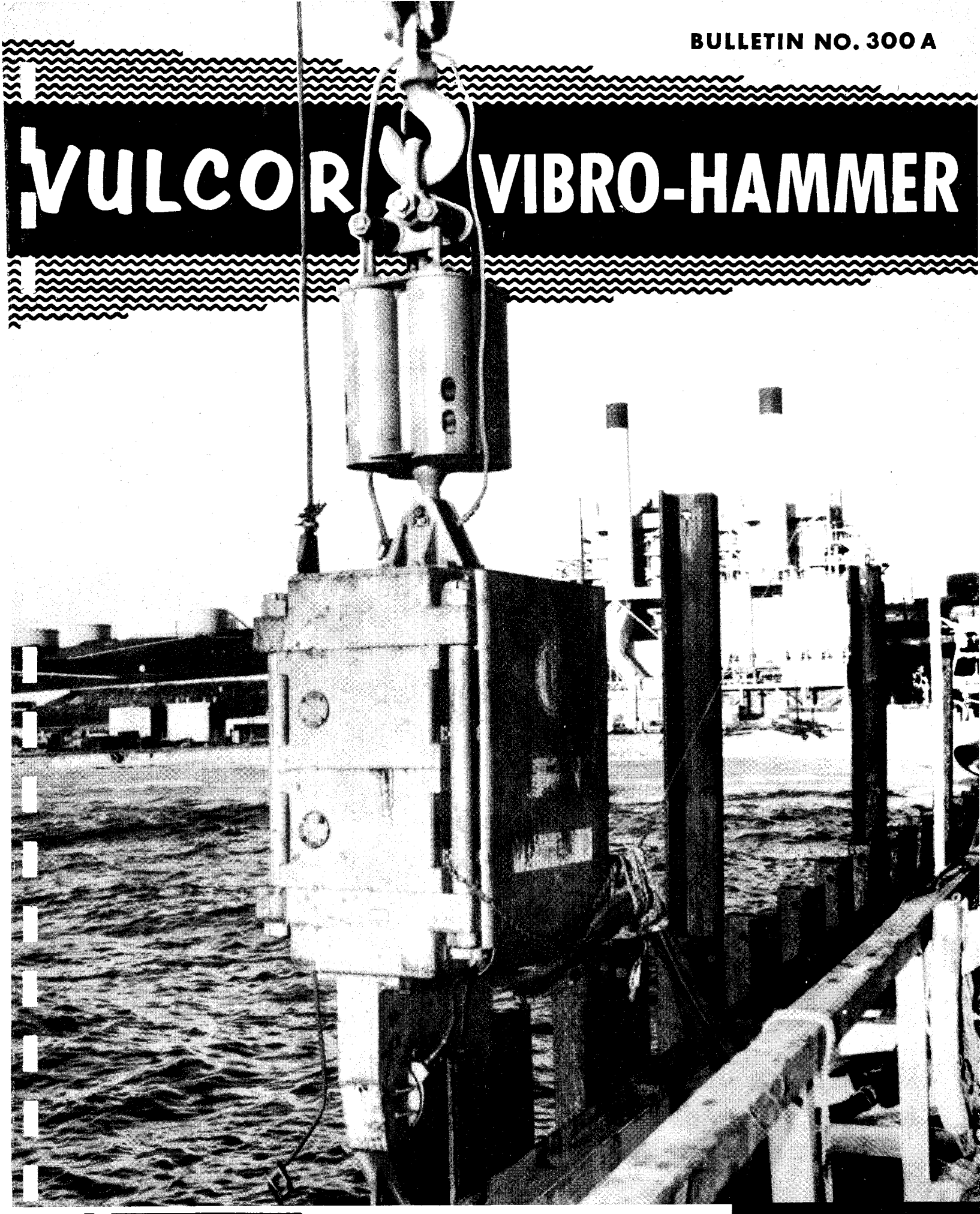
BULLETIN NO. 300 A

VULCOR VIBRO-HAMMER



VULCAN IRON WORKS INC.

Chattanooga

VULCAN IRON WORKS INC.

EXECUTIVE AND SALES OFFICES

2725 N. AUSTRALIAN AVE. WEST PALM BEACH, FLORIDA 33401

Phone: 305 842-1515 TWX 510 952-6668

The VULCAN IRON WORKS INC. is pleased to bring to the construction industry the VULCOR VIBRO-HAMMER. With this new type tool the American construction industry adds to its portfolio of tools another addition to further diversify and sharpen the ability of the contractor to effectively compete and effectively perform his function.

The VULCOR VIBRO-HAMMER is being exclusively distributed by the VULCAN IRON WORKS INC. in the United States and Canada under license from the THEW SHOVEL CO. of Lorain, Ohio.

The VULCOR VIBRO-HAMMER is designed to drive or extract different types of piles (sheet pile, steel pipe, steel H-pile, steel I-pile or concrete pile), by making use of the engineering principle that the resultant force obtained as a result of the centrifugal force in the upward and downward directions created by revolving a pair of eccentric weights simultaneously in opposite directions, thus cancelling the centrifugal forces in the horizontal directions.

Construction

In the Model VHD-1 the housing consists of a top section and a bottom section. These sections likewise form the top and bottom of the VHD-2 and the VHD-3. By the addition of one intermediate motor section to the VHD-1 the result is the VHD-2. Similarly by the addition of another motor section to the VHD-2 the result is the VHD-3. These additions and/or subtractions to change the basic size of the VULCOR VIBRO-HAMMER can readily be done in the field. This flexibility allows the contractor to selectively change the size of his VULCOR VIBRO-HAMMER to best suit the job conditions encountered.

Two induction motors are installed in each section and their respective shafts are held in place by knock-out pins and bolts. The rotating ring with eccentric weight is fitted onto each motor shaft and is supported in ball bearings.

For proper synchronization, each motor is fitted with a gear that is in mesh with the adjacent gear of the next motor. The gear teeth have standard profile with 20^{o} degree pressure angle, flame-hardened to withstand wear, and each gear is lubricated with "Pegasus Spray Lube."

Spherical roller bearings with grease lubrication are installed between the motor shaft and the rotating ring, and they have been selected for their ability to withstand severe vibrating load conditions.

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The terminal box for each pair of motors is fitted on the front side of the case and serves as a connection for the motor and power supply cables.

To prevent possible damage caused by vibration, the power supply cables are held to the case by wood cable clamps.

The hydraulic chuck unit is bolted to the underside of the bottom section of the case, and the chucking device itself is actuated by electro-hydraulic equipment.

A hydraulic cylinder and piston is fitted to the chuck and flexible high pressure hoses lead to the hydraulic pump.

Remote control equipment is at ground level and operates the chuck, so that the pile can be chucked from the controls.

The chuck itself, with serrated faces hardened to withstand wear, is designed to transmit full vibratory energy to the pile. The stroke of the chuck is 3 inches, so that a sheet pile or H-pile can be chucked directly. However, in the case of driving/extracting steel pipe or concrete pile, chucking is possible only with an adapter made for the purpose.

The maximum working pressure of the hydraulic pump is 9,950 lbs./sq. in., corresponding to a chucking force of 165 tons.

The pump starts and stops automatically by an adjustable pressure regulating switch, so that the hydraulic cylinder of the chucking device always operates at the proper pressure.

Bolting locations for the attachment of adapters or guide jaws are provided in four places on the rear side of the housing. Adapters are available to fit the VULCOR VIBRO-HAMMER to any conventional lead which normally accommodates VULCAN STEAM/AIR HAMMERS. Adapters for leads of other manufacturers are also available.

To minimize hammer vibration from being transmitted to the upper sheave and the crane, pile leads or tower, a spring-loaded damping device is installed above the VULCOR VIBRO-HAMMER housing and is fastened to it by removable pins. The damper consists of four coil springs having an allowable spring load of 29 tons. The damper is used only during the extraction of piles.

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The control switch board contains the following apparatus:

Magnetic Switch	Knife Switch
Thermal Relay	Cartridge Fuses (250V,
Time Relay	600A & 250V, 5A)
Current Transformer	Pilot Lamp
Ammeter (0 - 750 amps.)	Start-Stop Push-Button

The control switch board is a self-supported type and the pilot lamp, ammeter and start/stop push-button are arranged on the front panel.

The time relay enables the motors to energize in sequence once the starting push-button is activated.

VULCOR VIBRO - HAMMERS

SPECIFICATIONS

Model No. Size	VHD-1 40 HP	VHD-2 80 HP	VHD-3 120 HP
Dimensions & Weights			
Length Overall W/O Damper	5'-11-1/4"	7'-7"	9'-3"
Length Overall W/Damper	9'-11-1/4"	12'-7"	13'-3"
Width - Right to Left	3'-10"	3'-10"	3'-10"
Depth - Front to Back	3'-5"	3'-5"	3'-5"
Net Weight W/O Damper - Lbs.	8,379	11,907	15,435
Net Weight Damper - Lbs.	1,760	1,760	1,760
Net Weight of Switch Gear - Lbs.	780	780	780
Net Weight - Complete - Lbs.	11,600	15,460	19,360
Shipping Weight - Complete - Lbs.	12,000	16,000	19,750
Electrical Characteristics			
Aggregate Motor Horsepower	40	80	120
Voltage - Max.	220	220	220
Voltage - Min.	200	200	200
Motor R.P.M. - 60 Cycle	1,180	1,180	1,180
Motor R.P.M. - 50 Cycle	980	980	980
Cycle	60/50	60/50	60/50
Power Source KVA	100	125	150
Generator Size - K. W.	125	150	200
Number of Motors	2	4	6
Operational Characteristics			
Driving Force - Lbs. @ 60 Cycle	42,900	85,800	128,480
Driving Force - Lbs. @ 50 Cycle	29,480	59,180	88,660
Vibration Frequency - C.P.S. - 60 Cycle	19.7	19.7	19.7
Vibration Frequency - C.P.S. - 50 Cycle	16.3	16.3	16.3
Eccentric Moment - Lbs. In.	1,085	2,170	3,255
Damper Load - Max. - Tons	30	30	30

CONSTRUCTION OF VIBRO HAMMER

Electric Motor (Refer to Sheet 5 "Section of Electric Motor")

The electric motor of Uraga Vibro-Hammer is a special cage type induction motor consisted of a stator (3) with primary winding has fixed a shaft (1) and a rotor core (3) with secondary conductor has fitted an eccentric frame (4) which produce the vibratory force by its rotation around the shaft.

And the electric motors in pair are rotated in counter directions to each other and synchronized by the gears bolted with the rotating rings.

Casing (Refer to Sheet 2 and 3 "Outside View of Vibro-Hammer)

The casing is of cast iron and consists of a top casing (1), an upper intermediate casing (2), a lower intermediate casing (3), and a bottom casing (4) tied all together by tie bolts, and it is possible to change the assembly to bigger or smaller type of the vibro-hammer by taking off or adding one pair of motors and one intermediate casing in order to get suitable hammer for a given soil condition.

Guide Bracket

Four guides are fitted to the hammer casing so as to fit "D-22" diesel hammer leader.

Chucking Device and Hydraulic Pump

The pedestal of the chucking device is bolted under the bottom casing of the vibro-hammer, and the chucking device is operated by electro-hydraulic equipment.

The hydraulic cylinder with the piston and the chuck head is held by the pedestal and connected by high pressure rubber hoses to the oil hydraulic pump with handling devices set on the ground. So, it is easy to chuck the pile by handling on the ground.

The chuck head with serrated surface is hardened to avoid wear-down and enabled to transmit the vibratory motion to the pile completely. The stroke of the clutch head is designed 50 mm (about 2"), so sheet pile and H steel are able to be chucked directly, but steel pipe and concrete pole is chucked by means of special attachment.

Maximum working pressure of the pump is 600 kg/cm2 (8,500 P.S.I.) (corresponding chucking force 175 tons //380,000 lbs.//) at the discharge quantity of 0.4 ℓ/min.

Pump starts and stops automatically by adjustable pressure switch, so the oil cylinder of the chucking device is able to have always settled pressure.

The hydraulic rubber hoses connecting the oil pump and the hydraulic cylinder for the chucking device are sufficient for high pressure and consist of a unit pipe 6 m (20 ft.) long which can be jointed together for suitable length.

The joint parts of the hoses are connected tightly and easily by screw and have the non-return valves to protect oil leakage in the case of disconnection.

Damper

To isolate the hammer leader from vibration, spring acting damper is installed with pins on the top of the hammer casing. The damper consists of four coil springs with statical allowable spring load 27 tons (59,500 lbs.)

Control Switch Board

Control switch board contains the following apparatus:

Magnet contactor
Knife switch
Thermal relay
Time relay
Volt meter
Amper meter
Current transformer
Potential transformer
Knife switch with cover, for hydraulic pump
Push button switch
Pilot lamp
Fuse, for volt meter hydraulic pump control circuit

Control switch board is self-standing type and pilot lamp or push button are arranged on the front opening, ampere meter and volt meter can view through sighting window of the front opening.

Time relay enables motors to start sequently only by pushing start push buttons.

Cabtyre cables are connected with the terminals in the switch board through the side opening of the switch board.

PREPARATION OF DEVICES FOR DRIVING OR EXTRACTING

Prepare the devices as follows, besides a vibro-hammer with a chucking device, a hydraulic pump with rubber hoses and a control switch board.

Tower with Reader for driving in a Pile and Sheave Block (Refer to Sheet 1 "Outline and section of hammer leader")

For driving in a pile, prepare a tower similar to diesel hammer leader of D-22 type having sufficient strength for 9 tons (20,000 lbs) load, and install a sheave block with a suitable number of sheaves mentioned as follows on the top of the vibro-hammer by the shackel or the eye-piece.

$$\text{Number of winding ropes} = \frac{\text{hammer weight} + \text{pile weight}}{0.8 \times (\text{rope tension of winch})}$$

Tower for Extracting a Pile and Sheave Block

For extracting a pile, prepare a damper and a tower having sufficient strength for 25 tons (55,000 lbs) load, and install a sheave block with suitable number of sheave mentioned as follows on the top of the damper fitted on the vibro-hammer.

$$\text{Number of winding ropes} = \frac{\text{resistance force 25 tons (55,000 lbs) caused by driving out a pile}}{0.8 \times (\text{rope tension of winch})}$$

Attention! Install the damper between the vibro-hammer and the sheave block.

Electric Supply and Cabtyre Cable

Electric Supply for vibro-hammer -- Use three-phase alternative electric current of 50 c/s 200 V or 60 c/s 220V and prepare necessary capacity of the electric source which should not be less than

Model of Vibro-Hammer \ Type of Electric Source	Potential Transformer	Portable Generator
VHD-1	100 KVA	120 KW
VHD-2	125 KVA	150 KW
VHD-3	150 KVA	200 KW

Allowable fluctuation of the voltage is within $\pm 10\%$

Cabtyre Cable from Transformer to Control Switch Board

Use cabtyre cable having the sectional area not less than
60 mm2 (C.M. 118 x 10^3) for VHD-1
125 mm2 (C.M. 246 x 10^3) for VHD-2
200 mm2 (C.M. 395 x 10^3) for VHD-3
And install the transformer at the distance less than 50 m (165 ft) from the control switch board for the vibro-hammer.

Attention! The cabtyre cables should not be coiled.

Cabtyre Cable from Control Switch Board to Vibro-Hammer

When the cabtyre cables having three cores are connected respectively to the electric motors in the vibro-hammer, each sectional area of those cables should not be less than 60 mm2 (C.M. 118 x 10^3). And when those cables are for one pair of the electric motors respectively, that sectional area should not be less than 60 mm2 (C.M. 118 x 10^3).

Connection of Between Lead Wires of Electric Motor and Terminals

Lead wires of each phase of motor (U phase is coloured red, V phase is coloured white, and W phase is coloured black) are connected by cabtyre cables with the respective phase of terminals in the control switch board. And the rotating direction of the electric motor is marked on the side of the rotating ring.

Electric Supply for Hydraulic Pump

The electric source for the electric motor of the hydraulic pump shall be 50 c/s 200 V or 60 c/s 220 V of single phase fed by the control switch board.

PREPARATION OF WORKING FOR DRIVING IN PILE

Prepare the works in accordance with the following order:

A) Fit the vibro-hammer with the leader of the tower by the guide bracket; that is, the lifting wire rope shall be reeved in the sheave block, the vibro-hammer shall be hung underneath the sheave block by the shackel or the eye piece, and the vibro-hammer shall be fitted with the leader by the guide bracket.

B) Wind up the vibro-hammer high enough to clear the length of the pile and then brake the winch.

C) Hand the pile underneath the vibro-hammer by an auxiliary line of the winch.

D) Chuck the pile by the chucking device. That is done in accordance with the following order:- (Refer to Sheet 4 "Outside View of Hydraulic Pump")

1. Start the electric motor for the hydraulic pump and keep the electric supply going during the work of driving in the pile.

2. Full open the vent valve (6).

3. Adjust the pressure switch (3) so as to indicate:
   about 280 kg/cm2 (4,000 psi) for VHD-2
   about 420 kg/cm2 (6,000 psi) for VHD-3

4. Close the return oil handle (1).

5. Turn the lever on the four way valve "2" to the direction of the delivery side for drawing the chucking head in.

6. Put the top of the pile in the chucking heads.

7. Close the chucking device. That is, turn the lever on the four way valve "2" the direction of the delivery side for drawing the chucking head out.

When the cylinder oil pressure of the chucking device is increased above the setting pressure the electric motor is to be stopped automatically, and, if the oil pressure is decreased during the operation, the motor is to be started automatically and then the pressure is to be kept at the adjusted pressure always.

WORKING FOR DRIVING IN PILE

Perform the work for driving in a pile in accordance with the following order:

1. Release the winch from braking, then the pile bottom will be sunk slightly by the weights of the pile and the Vibro-Hammer.

2. Switch the electric motors of the Vibro-Hammer on by pushing the start push button (coloured black) on the front, then - (refer to the sheet 8 "Wiring Diagram")

In the case of VHD-3,

After 8 seconds - 15 seconds from switch the pair of the motors (IM, and IM_2) in the first layer on, the motors (IM_3 and IM_4) in the second layer will be switch on automatically, and after 10 seconds - 12 seconds from that time the motors (IM_5 and IM_6) in the third layer will be switched on automatically.

In the case of VHD-2,

After 8 seconds - 15 seconds from switch the motor (IM_1) on, the motor (IM_2) will be automatically switched on, and the motors (IM_3 and IM_4) will be automatically switch on after 10 seconds - 12 seconds from that time.

In the case of VHD-1,

After 8 seconds - 15 seconds from switch the motor (IM_1) on, the motor (IM_2) will be automatically switched on.

3. When the pile is driven into the ground to a given depth, push the button (colored red) and stop the motors of the Vibro Hammer.

4. Hang the pile by the winch slightly and brake the winch.

5. Release the pile from the chucking device of the vibro-hammer.

PREPARATION OF WORKING FOR EXTRACTING PILE

Prepare the works in accordance with the following order:

A) HANG the vibro-hammer through the damper and the sheave block from the top of the tower by the winch. The leader is not necessary for extracting.

B) CHUCK the pile by the chucking device of the vibro-hammer. (Methods of chucking the pile is within Paragraph D of the last topic on Page 8.)

WORKING FOR EXTRACTING PILE

Perform the work for extracting a pile in accordance with the following order:

A) Hang the pile by the winch slighty as the damper spring will be compressed to deform by about 100 mm (4 in) and brake the winch.

B) Switch the electric motors of the vibro-hammer on by pushing the start push button (coloured black) on the front, then each motor will be started automatically and gradually as written in Paragraph 2 of WORKING FOR DRIVING IN PILE on Page 9.

C) Keep the vibration going for several minutes without drawing the pile off by driving the winch until the electric current goes down and keep steady, in order to decrease the resistance force between pile surfaces and the ground. And then, winding the vibro-hammer up gradually by the winch.

Switch the electric motors off, however, when the electric current does not go down within 10 seconds, and switch on again after several minutes.

D) Switch the electric motors off by pushing the stop push button (coloured red) on the front, after about 30% of the depth of the pile driven in the ground has been drawn up, which percentage of the depth will differ according to the soil condition, the type of pile and the total depth of the pile, then the rest of the pile can be drawn up by the winch only.

E) Stop and brake the winch after the vibro-hammer is drawn up as long as possible.

F) Fit the wire rope from the auxiliary drum of the winch with the pile and make the wire rope tense.

G) Release the pile from the chucking device of the vibro-hammer, using the method described in Paragraph D of PREPARATION OF WORKING FOR DRIVING IN PILE on Pages 8 and 9.

REASSEMBLING THE ONE TYPE OF VIBRO-HAMMER TO THE OTHER TYPE OF CAPACITY

This vibro-hammer can be reassembled to the other type so as to suit the soil conditions.

Reassembling Methods from VHD-3 to VHD-2 or VHD-1 (Refer to Sheet 2 and 3 "Outside View of Vibro-Hammer)

A) Take the tie bolts (8c) off.
B) Take the top casing (1) off.
C) Take off the upper casing with 3rd layer's motors IM5 and IM6 and/or the lower intermediate casing with 2nd layer's motors IM3 and IM4.

Attention! Each electric motor has its own rotating direction, so the location in horizontal or in vertical position should not be changed. If it is necessary to change the motor's combination due to some trouble, the peculiar rotating direction of the motor in the location should be kept.

D) Put the top casing (1) on the lower intermediate casing or on the bottom casing, and tie all together by the tie bolts (8b) for VHD-2 or 8a for VHD-1.
E) Connecting methods of the cabtyre cables are shown on Sheet 8 "Wiring Diagram."

Reassembling Methods from VHD-1 to VHD-2 or VHD-3

A) Take the tie bolts (8a) off.
B) Take the top casing (1) off.
C) Put the lower intermediate casing with the 2nd layer's motors IM3 and IM4 and in case of VHD-3 the upper intermediate casing with the 3rd layer's motors IM5 and IM6 on the bottom casing.
D) Put the top casing on the lower intermediate casing or on the upper intermediate casing, and tie all together by the tie bolts (8b) for VHD-2 or 8c for VHD-3.
E) Connecting methods of the cabtyre cables are shown on Sheet 8 "Wiring Diagram."

MAINTENANCE AND INSPECTION

Before service, the following should be inspected and adjusted, if necessary:
A) Tightness of every bolt and nut
B) Connection of every electric cable
C) Tightness of every joint of the hydraulic rubber hose.
D) Oil level for the hydraulic pump (The pump shall be full of the oil up to oil level plug.)

Take off the vent hole covers on the vibro-hammer casing, during the service of driving or extracting a pile.

Supply the lubricating oil for the gears in the vibro-hammer occasionally from the holes of the oil supply on the side of the vibro-hammer casings. Lubricating oil shall be "Moly Spray Kote" produced by Alpha Moly Kote Co., Ltd.

Overhaul and inspect the roller bearings of the electric motors at intervals between the operating times 100 - 120 hrs. and grease them. The grease for the roller bearings shall be "Code 5480 Stable-Lith E.P. # 2 Grease" produced by South West Grease & Oil Co., Inc. No other grease should be used.

The oil for the hydraulic pump shall be Mobil D.T.E. Light. When another kind of oil must be used remnant oil in the oil tank, the pump, the hoses and the cylinder should be completely taken off and their contact surface should be cleaned up. No mixed oil should be used.

Connection of the electric wires in the control switch board shall be shown as in Sheet 8 "Wiring Diagram."

Connection of the electric wires in the electric motor for the hydraulic pump shall be as shown on the inside surface of the terminal cover.

Attention is called to the following matters to assemble the electric motors and the gears in the vibro-hammer, after their overhauling and inspection:

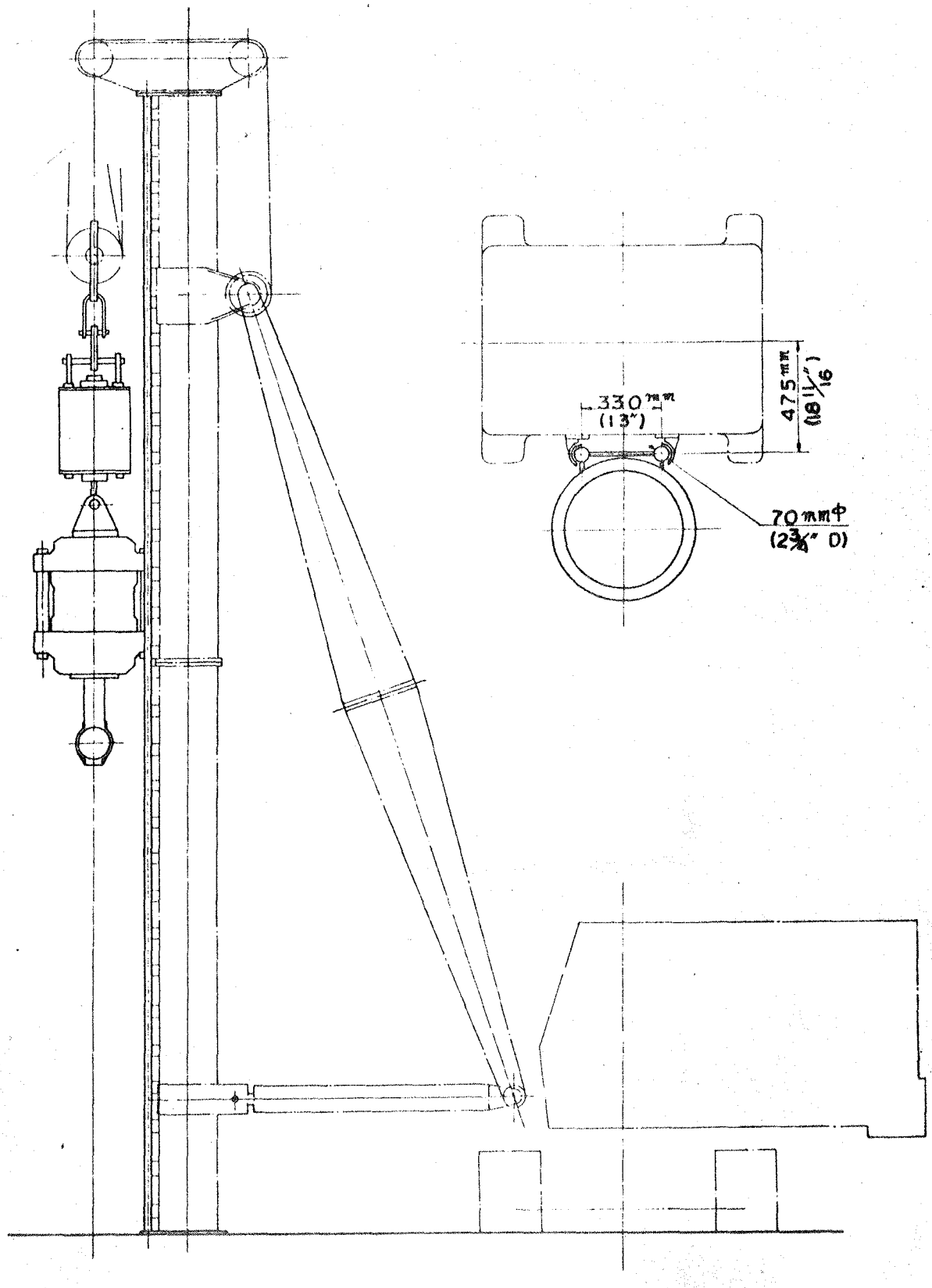
A) Combination of the electric motors and their gears shall be as shown in Sheet 2 and 3.

B) Directions of the eccentric weights integral with the rotating rings of the electric motors shall be lowered horizontally.

C) The electric motors shall be fitted as one pair in the layer and then the layers shall be assembled.

SHEET 1

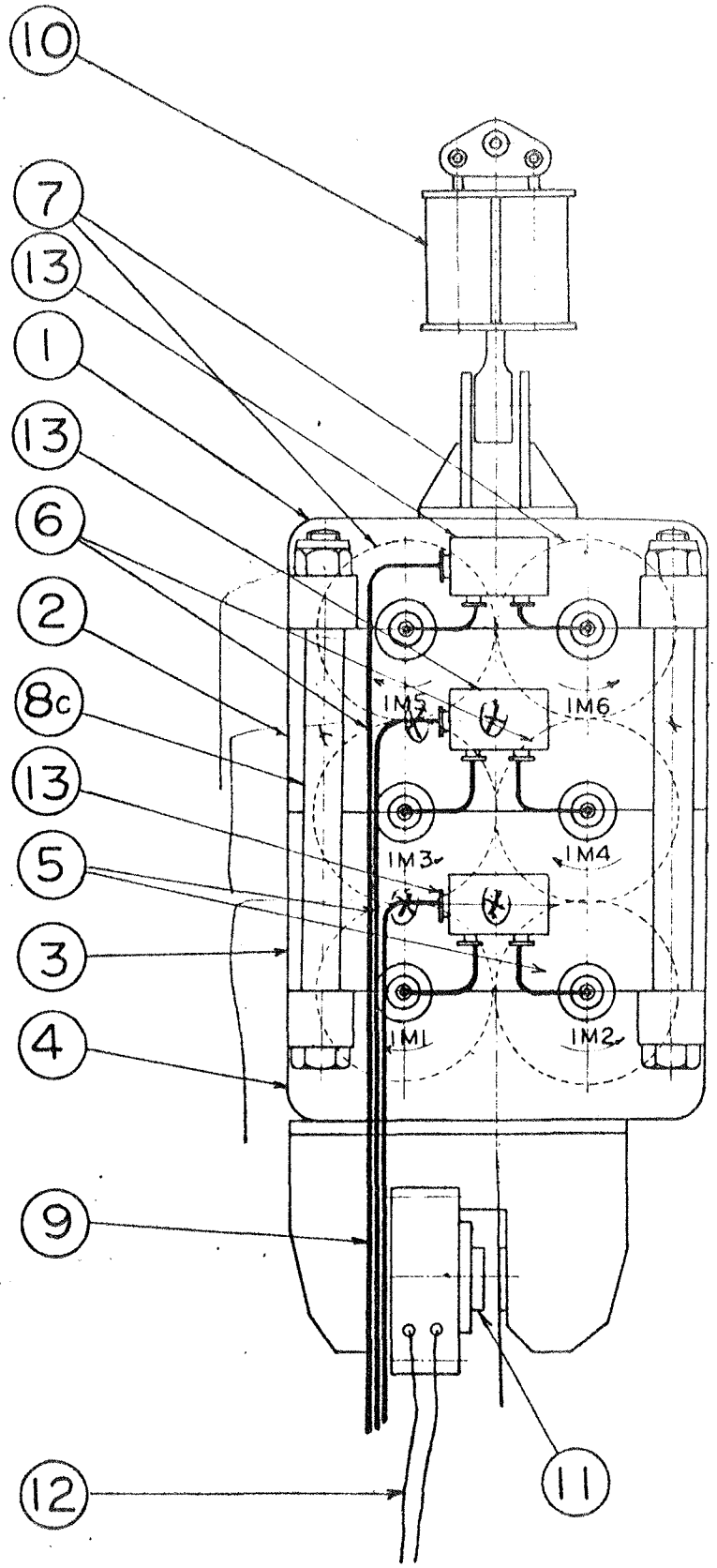
OUTLINE AND SECTION OF HAMMER LEADER



SHEET 2

OUTSIDE VIEW OF VIBRO-HAMMER (1)

VHD – 3



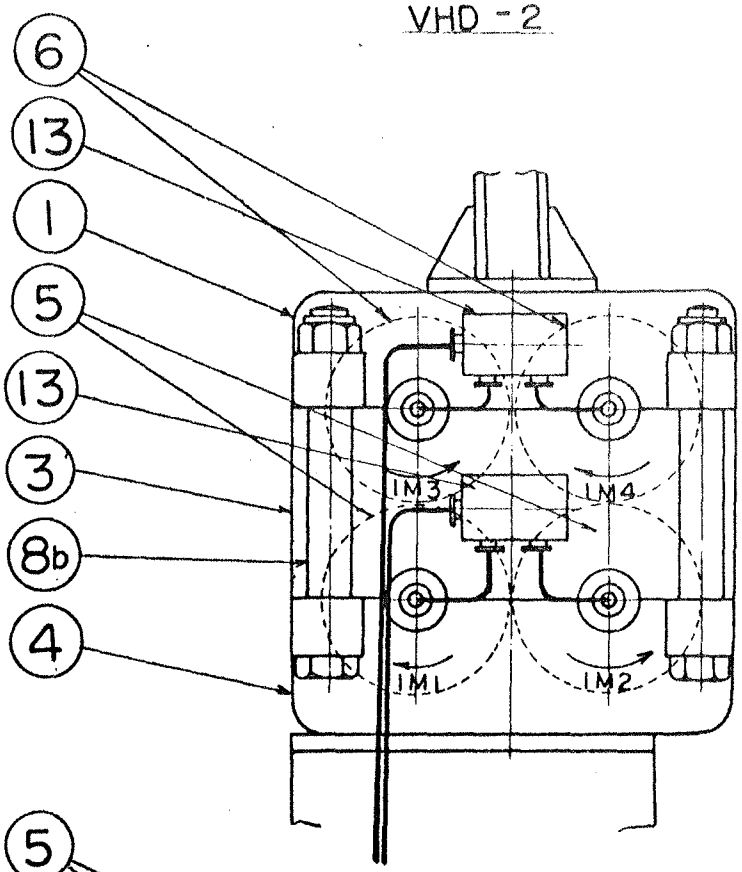
ECR VHD1 → FROM VHD3
- REMOVE: 2 INTERMEDIATE SECTION
LOWER MOTORS (4)
LOWER STARTING BOX (2)

MARK	N A M E
1	TOP CASING
2	UPPER INTERMEDIATE CASING
3	LOWE INTERMEDIATE CASING
4	BOTTOM CASING
5	1st. STAGE MOTOR
6	2nd. STAGE MOTOR
7	3rd. STAGE MOTOR
8	TIE BOLT
9	CABTYRE CABLE
10	DAMPER
11	HYDRAULIC CYLINDER
12	HYDRAULIC RUBBER HOSE
13	TERMINAL BOX

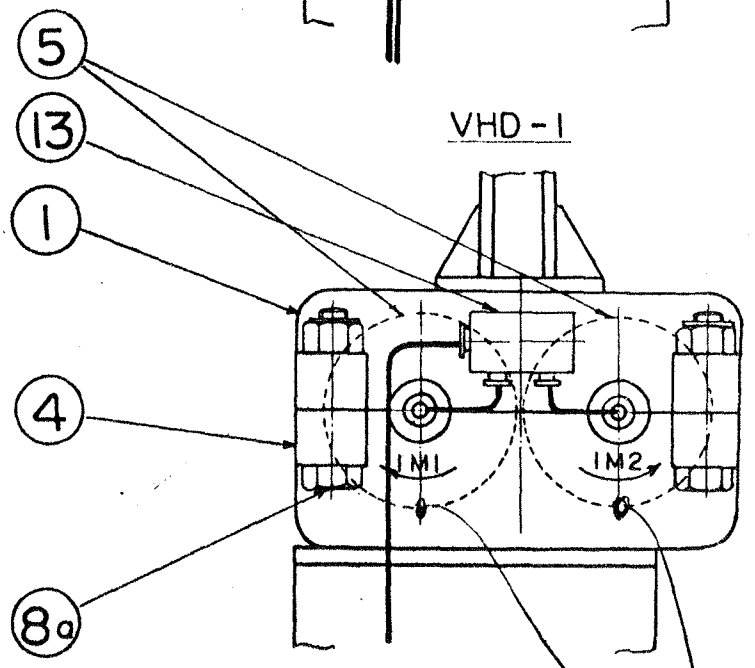
SHEET 3

OUTSIDE VIEW OF VIBRO-HAMMER (2)

VHD - 2



VHD - 1

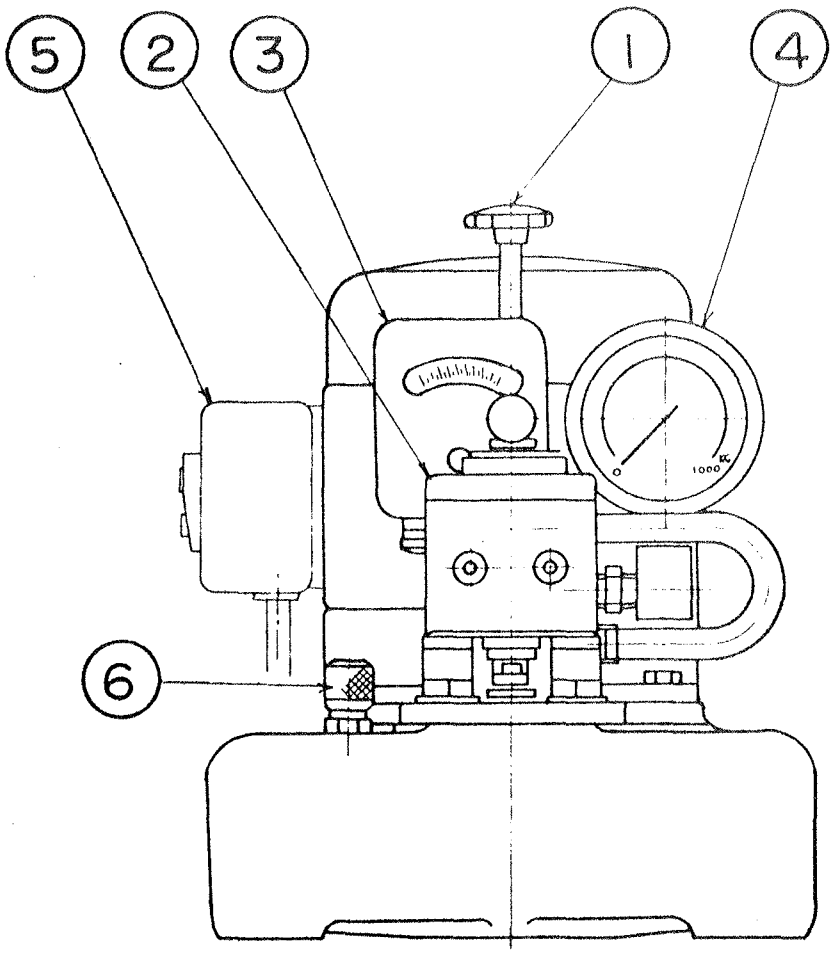


IMPORTANT

1. KEEP ECCENTRIC SIDE BOTH UP OR BOTH DOWN.
2. MATCH SCRIBE ON GEARS
3. TIGHTEN BOLTS TIGHTLY USE TORQUE WRENCH.
4. KEEP POWER IN PHASE.

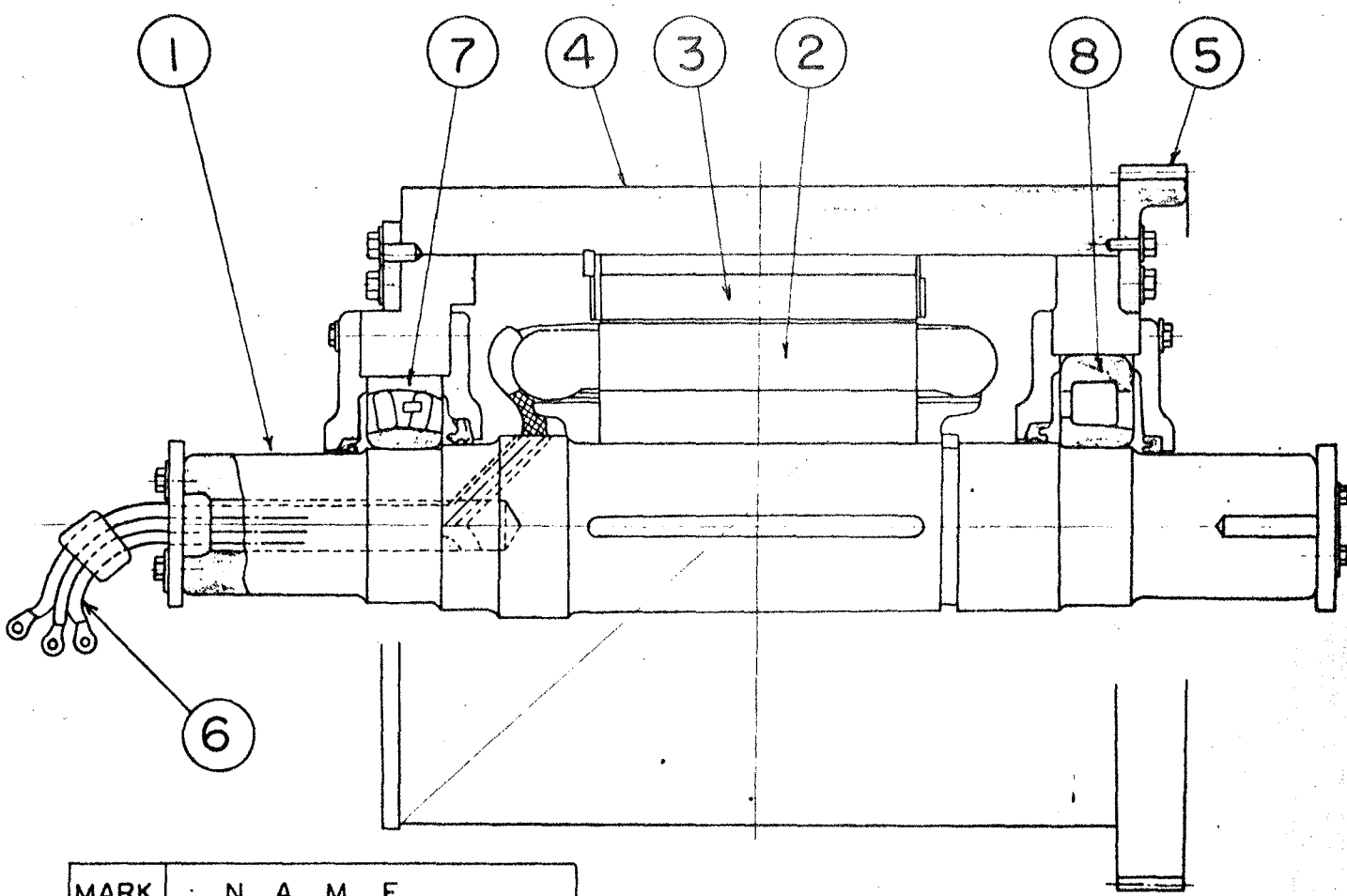
SHEET 4

OUTSIDE VIEW OF OIL HYDRAULIC PUMP



MARK	N A M E
1	RETURN-OIL HANDLE
2	FOUR WAY VALVE
3	PRESSURE SWITCH
4	PRESSURE GAUGE
5	SWITCH
6	VENT VALVE

SHEET 5 SECTION OF ELECTRIC MOTOR



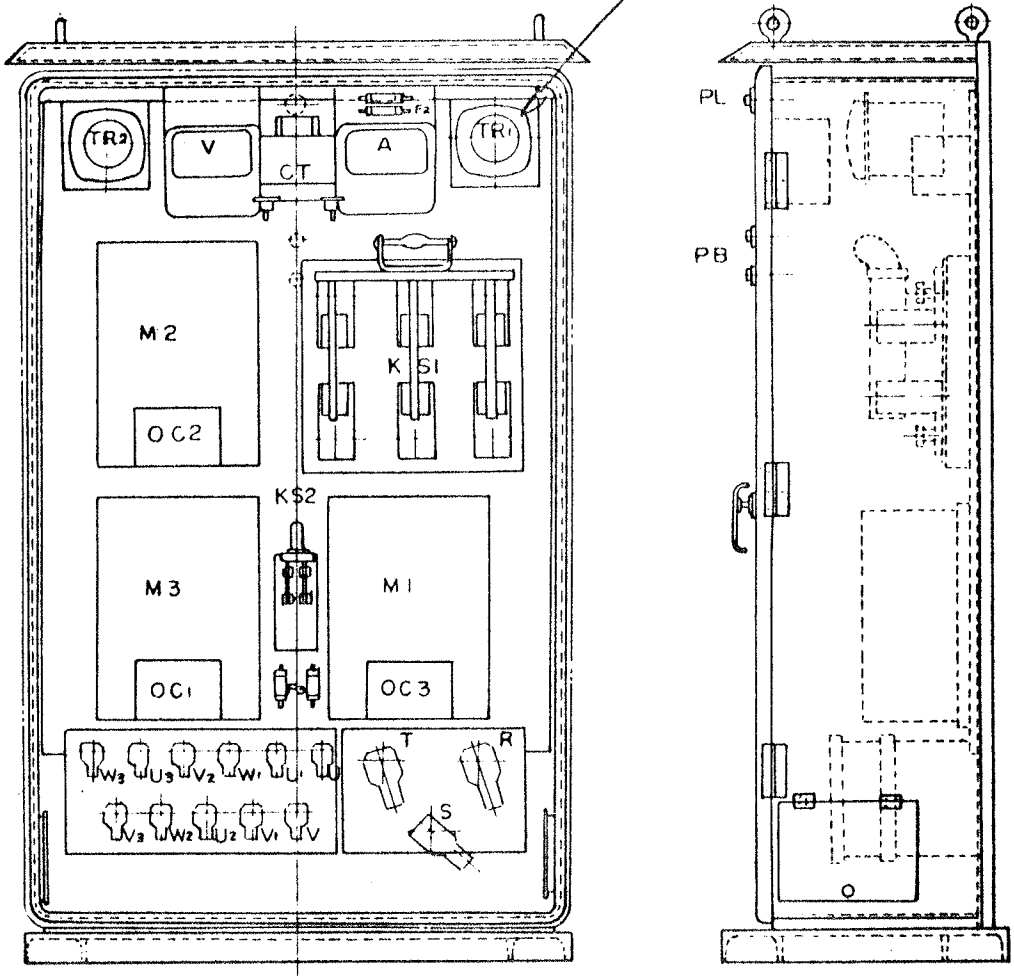
MARK	N A M E
1	SHAFT
2	STATOR CORE
3	ROTOR CORE
4	FRAME
5	GEAR
6	LEAD WIRE
7	SPHERICAL ROLLER BEARING
8	ROLLER BEARING

SHEET 6

FRONT VIEW OF CONTROL SWITCH BOARD

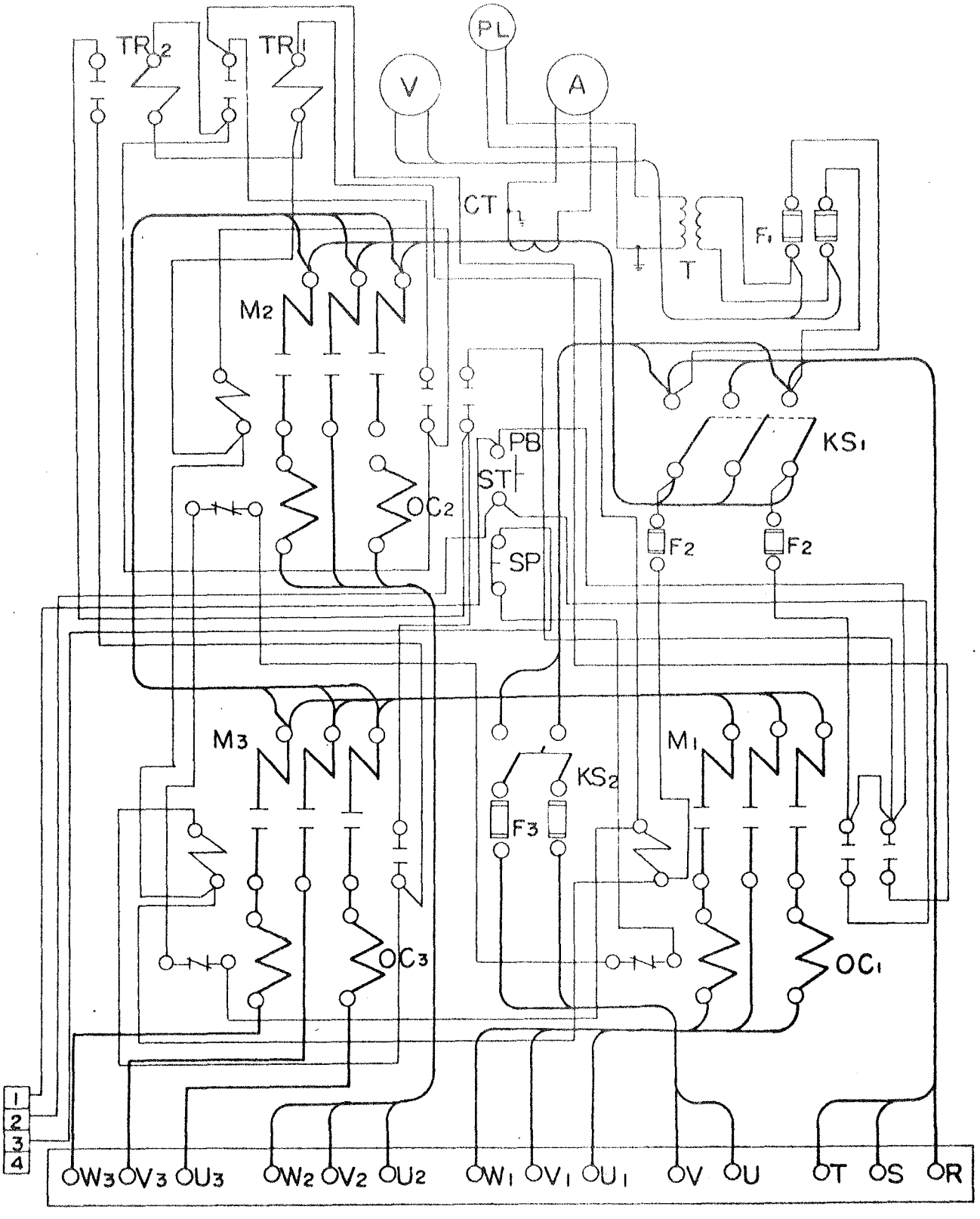
PRACTICAL TR1 — 20 sec.
TR2 — 15 sec.

(60) sec. MAX (15-20)

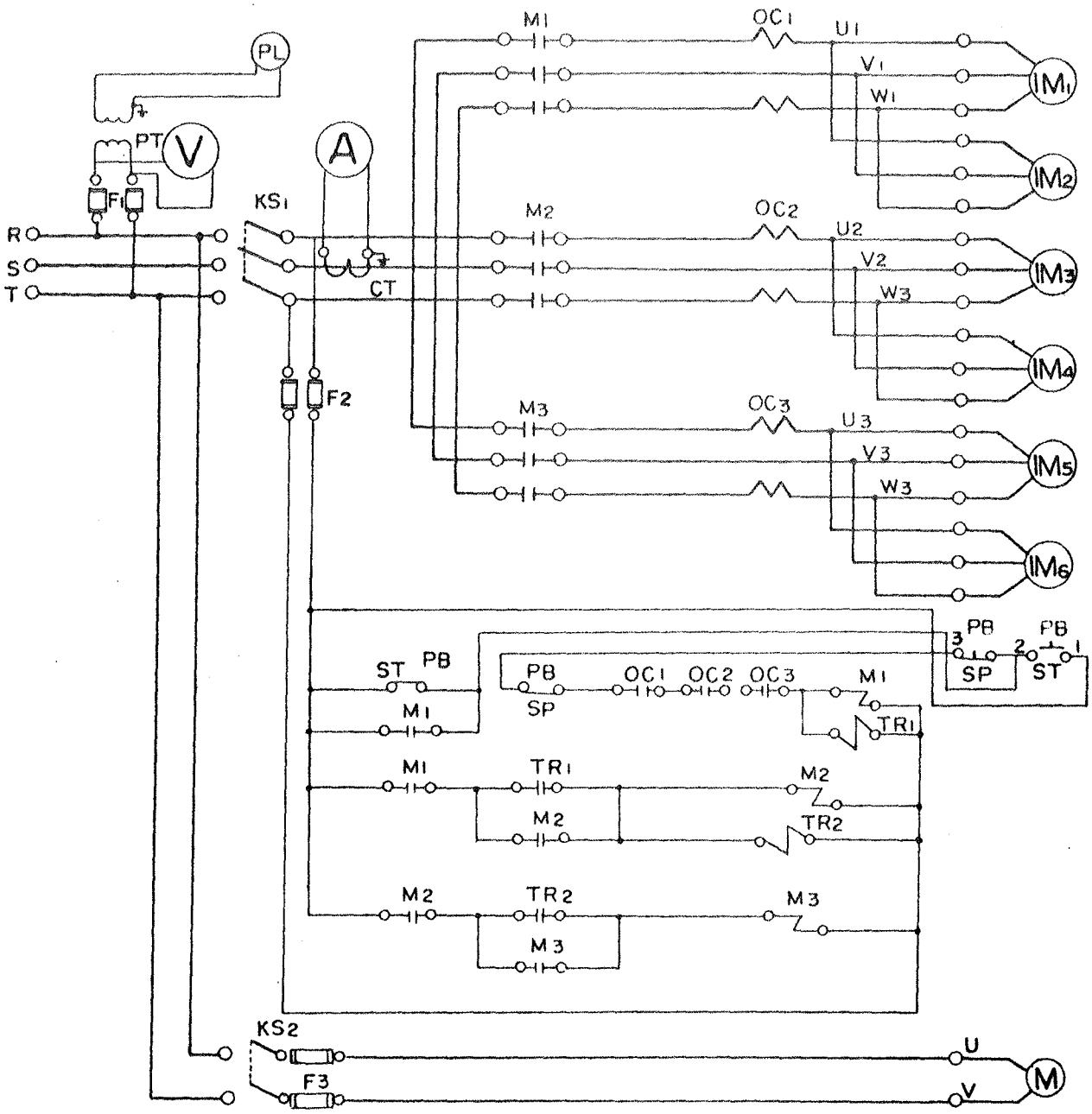


SHEET 7

CONNECTION DIAGRAM OF CONTROL SWITCH BOARD



SHEET 8 WIRING DIAGRAM



TERMINAL CONNECTION

VHD - 3

MARK OF TERMINAL	MOTOR	COLOR OF LEAD WIRE
U1	IM1 & IM2	RED
V1	"	WHITE
W1	"	BLACK
U2	IM3 & IM4	RED
V2	"	WHITE
W2	"	BLACK
U3	IM5 & IM6	RED
V3	"	WHITE

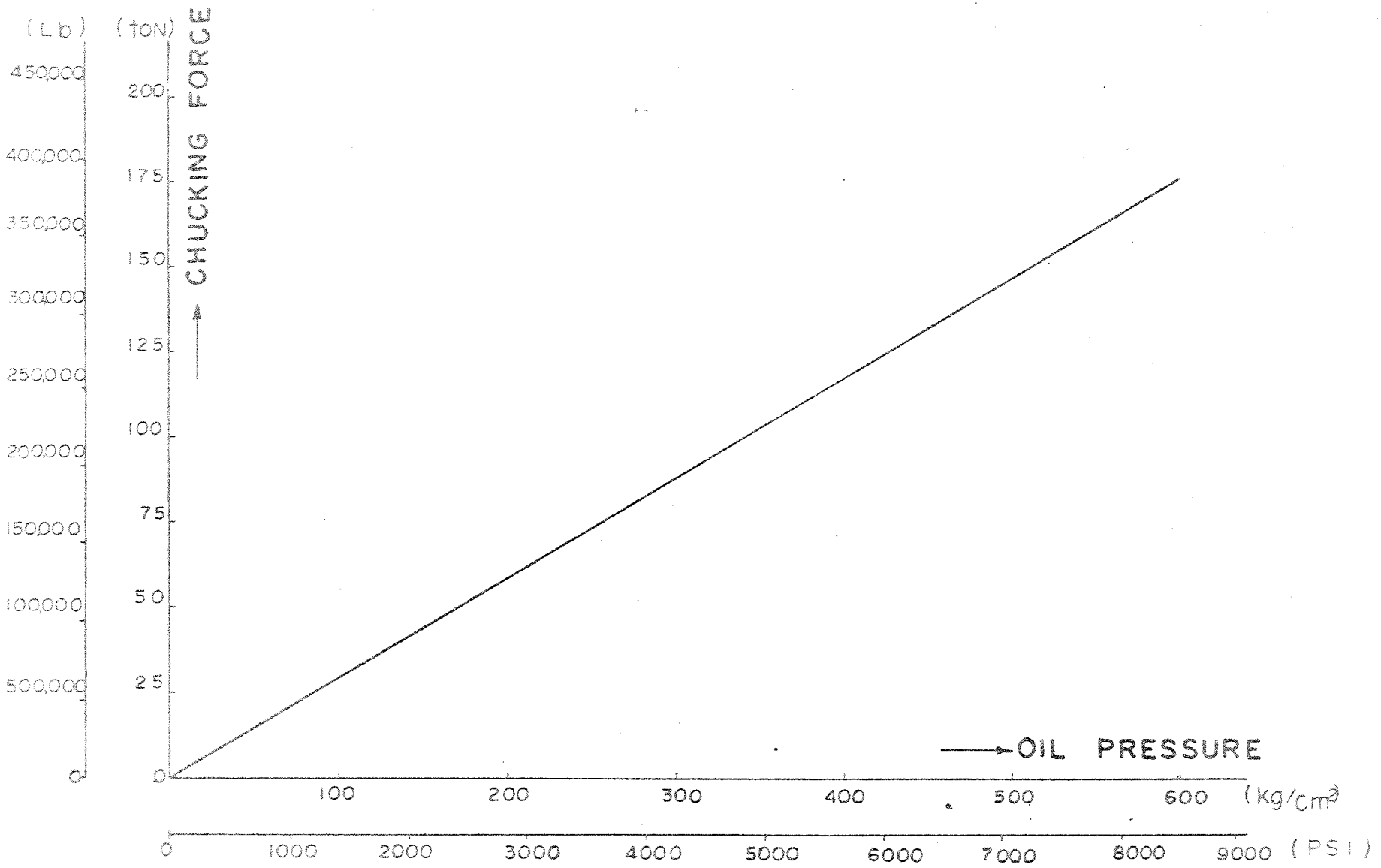
VHD - 2

MARK OF TERMINAL	MOTOR	COLOR OF LEAD WIRE
U1	IM1 & IM2	RED
V1	"	WHITE
W1	"	BLACK
U2	IM3 & IM4	RED
V2	"	WHITE
W2	"	BLACK

VHD - 1

MARK OF TERMINAL	MOTOR	COLOR OF LEAD WIRE
U1	IM1 & IM2	RED
V1	"	WHITE
W1	"	BLACK

SHEET 9 CHART FOR OIL PRESSURE V S. CHUCKING FORCE



Ability of URAGA Vibro-Hammer for Driving or Extracting Several Kinds of Pile Into or Out of the Ground with Certain Soil Conditions

It is very difficult to define the ability of each type of URAGA Vibro-Hammer due to the complicated composition of the soil, so the abilities shall be concluded by taking into account the aspects of the soil compositions, i.e., distributions of water, sand, clay, etc., and those qualities. To help determine the vibro-hammer type to be used in a given place, referable data based upon the experiences are shown as follows:

(1) LIMITS OF THE ABILITIES OF THE HAMMER FOR DRIVING PILES INTO SANDY GROUND

Mark o: possible to drive in Mark x: impossible to drive in

Kind of Pile	Type or Dimension mm (in)	Length m (ft)	VHD-1 Hardness of Ground				VHD-2 Hardness of Ground				VHD-3 Hardness of Ground			
			Soft	Medium	Hard	Very Hard	Soft	Medium	Hard	Very Hard	Soft	Medium	Hard	Very Hard
Sheet Pile	I	12(40)	o	o	x	x	o	o	o	x	o	o	o	o
	II	12(40)	o	o	x	x	o	o	o	x	o	o	o	o
	III	12(40)	o	o	x	x	o	o	o	x	o	o	o	o
	IV	12(40)	o	x	x	x	o	o	x	x	o	o	o	x
	V	12(40)	o	x	x	x	o	o	x	x	o	o	o	x
Steel Pipe (opened end)	400ø(16D)	15(50)	o	x	x	x	o	o	x	x	o	o	o	x
	500ø(20D)	15(50)	o	x	x	x	o	o	x	x	o	o	o	x

Kind of Pile	Type or Dimension mm (in)	Length m (ft)	VHD-1 Hardness of Ground				VHD-2 Hardness of Ground				VHD-3 Hardness of Ground			
			Soft	Medium	Hard	Very Hard	Soft	Medium	Hard	Very Hard	Soft	Medium	Hard	Very Hard
Steel Pipe (closed end)	300ϕ(12D)	15(50)	o	x	x	x	o	o	x	x	o	o	x	x
	400ϕ(16D)	15(50)	x	x	x	x	o	x	x	x	c	o	x	x
H steel	300 (12)	15(50)	o	o	x	x	o	o	x	x	o	o	o	x
	400 (16)	15(50)	o	x	x	x	o	o	x	x	o	o	x	x
Concrete Pole	300ϕ(12D)	10(33)	o	x	x	x	o	o	x	x	o	o	x	x
	400ϕ(16D)	12(40)	x	x	x	x	o	x	x	x	o	o	x	x
Wooden Pole	200ϕ (8D)	7(23)	o	o	x	x	o	o	o	x	o	o	o	o

NOTE: The expressions of ground hardness in the above table correspond with the following hammering numbers N by Reymond sampler in standard penetration test:-

Soft	:-	N ‹ 10	)
Medium	:-	N = 10 - 30	)
Hard	:-	N = 30 - 50	) in sandy ground
Very Hard	:-	N = 50 - 60	)

(2) LIMITS OF THE ABILITIES OF THE HAMMER FOR EXTRACTING PILES OUT OF SANDY GROUND

Mark o: possible to drive out Mark x: impossible to drive out

Kind of Pile	Type or Dimension mm (in)	Length	VHD-1 Hardness of Ground				VHD-2 Hardness of Ground				VHD-3 Hardness of Ground
			Soft	Medium	Hard	Very Hard	Soft	Medium	Hard	Very Hard	
Sheet Pile	I	12(40)	o	o	o	x	o	o	o	o	VHD-2 can almost extract the piles mentioned in this table, so it is unnecessary to use VHD-3.
	II	12(40)	o	o	o	x	o	o	o	o	
	III	12(40)	o	o	o	x	o	o	o	o	
	IV	12(40)	o	o	x	x	o	o	o	o	
	V	12(40)	o	o	x	x	o	o	o	o	
Steel Pipe	400ϕ(16D)	15(50)	o	o	x	x	o	o	o	o	
	500ϕ(20D)	15(50)	o	o	x	x	o	o	o	o	
H Steel	300 (12)	15(50)	o	o	x	x	o	o	o	o	
	400 (16)	15(50)	o	o	x	x	o	o	o	o	

(3) LIMITS OF THE ABILITIES OF THE HAMMER FOR DRIVING PILES INTO CLAYEY GROUND

Mark o: possible to drive in Mark x: impossible to drive in

Kind of Pile	Type or Dimension mm (in)	Length m (ft)	VHD-1 Hardness of Ground				VHD-2 Hardness of Ground				VHD-3 Hardness of Ground			
			Soft	Medium	Hard	Very Hard	Soft	Medium	Hard	Very Hard	Soft	Medium	Hard	Very Hard
Sheet Pile	I	12(40)	o	o	x	x	o	o	o	x	o	o	o	x
	II	12(40)	o	o	x	x	o	o	o	x	o	o	o	x
	III	12(40)	o	o	x	x	o	o	o	x	o	o	o	x
	IV	12(40)	o	o	x	x	o	o	x	x	o	o	o	x
	V	12(40)	o	o	x	x	o	o	x	x	o	o	o	x
Steel Pipe (open end)	400ø(16D)	15(50)	x	x	x	x	o	o	x	x	o	o	o	x
	500ø(20D)	15(50)	x	x	x	x	o	o	x	x	o	o	o	x
Steel Pipe (closed end)	300ø(12D)	15(50)	x	x	x	x	o	x	x	x	o	o	x	x
	400ø(16D)	15(50)	x	x	x	x	o	x	x	x	o	o	x	x
H Steel	300 (12)	15(50)	o	o	x	x	o	o	o	x	o	o	o	x
	400 (16)	15(50)	o	o	x	x	o	o	o	x	o	o	o	x
Concrete Pole	300ø(12D)	10(33)	o	x	x	x	o	o	x	x	o	o	o	x
	400ø(16D)	12(40)	x	x	x	x	o	x	x	x	o	o	x	x
Wooden Pole	200ø (8D)	7(23)	o	o	x	x	o	o	x	x	o	o	o	x

Note: The expressions of ground hardness in the above table correspond with the following hammering numbers N by Reymond Sampler in standard penetration test:-

Soft	:-	N < 4	)
Medium	:-	N = 4 - 8	)
Hard	:-	N = 8 - 15	) in clayey ground
Very Hard	:-	N = 15 - 30	)

(4) LIMITS OF THE ABILITIES OF THE HAMMER FOR EXTRACTING PILES OUT OF CLAYEY GROUND

Kind of Pile	Type or Dimension mm (in)	Length m (ft)	VHD-1 Hardness of Ground				VHD-2 Hardness of Ground				VHD-3 Hardness of Ground
			Soft	Medium	Hard	Very Hard	Soft	Medium	Hard	Very Hard	
Sheet Pile	I	12(40)	o	o	o	x	o	o	o	o	VHD-2 can almost extract the piles mentioned in this table out, so it is unnecessary to use VHD-3.
	II	12(40)	o	o	o	x	o	o	o	o	
	III	12(40)	o	o	o	x	o	o	o	o	
	IV	12(40)	o	o	o	x	o	o	o	o	
	V	12(40)	o	o	o	x	o	o	o	o	
Steel Pipe	400ϕ(16D)	15 (50)	o	o	x	x	o	o	o	o	
	500ϕ(20D)	15 (50)	o	o	x	x	o	o	o	o	
H Steel	300 (12)	15(50)	o	o	x	x	o	o	o	o	
	400 (16)	15(50)	o	o	x	x	o	o	o	o	

(Mark o: possible to drive out; Mark x: impossible to drive out)

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