JIUN MASUDA
CONSULTING ENGINEER
MARUNOUCHI, TOKIO

CALCULATIONS FOR

MADE BY________ DATE________ FILE NO________
CHECKED BY________ DATE________ PAGE NO________

父 金山

渡津橋 設計（昭和　年）

「機械」

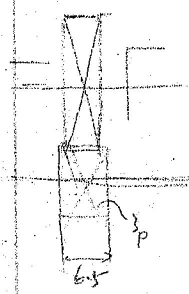
昭和六年十月

イコレイター	41回=不等 全部
クラッチ	28回=少々変更

ベベスモール

赤才 R₂₅C°₂ 要（ボール付）	3,100#
〃 R₂₅C°₂	243.
其余 リンク　か係多	7139.
	10,482#

ギアーフレーム（鋳造鋼） 1,273#



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JIJI BLDG, TOKYO

MADE BY _____ DATE 6-10-31 FILE NO _____

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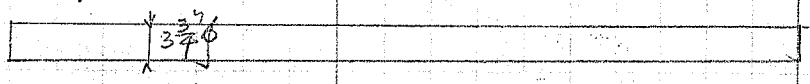
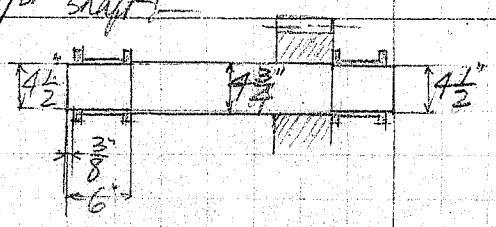
CALCULATIONS FOR

SHAFT

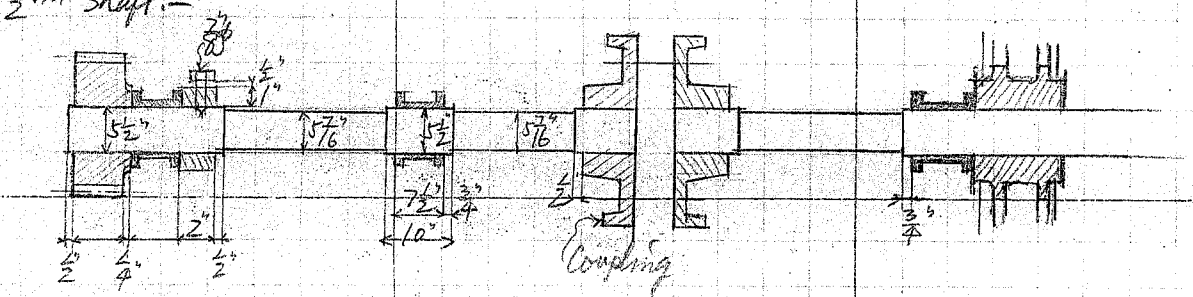
Motor shaft:—



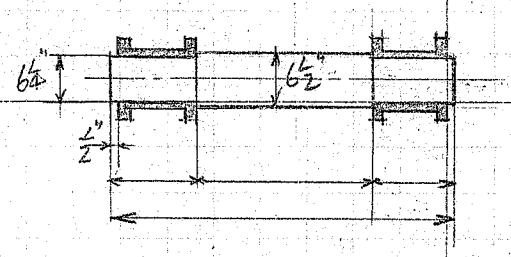
1st shaft:—



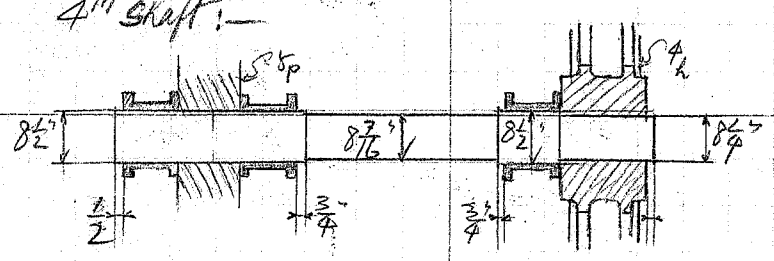
2nd shaft:—



3rd shaft:—



4th Shaft:—



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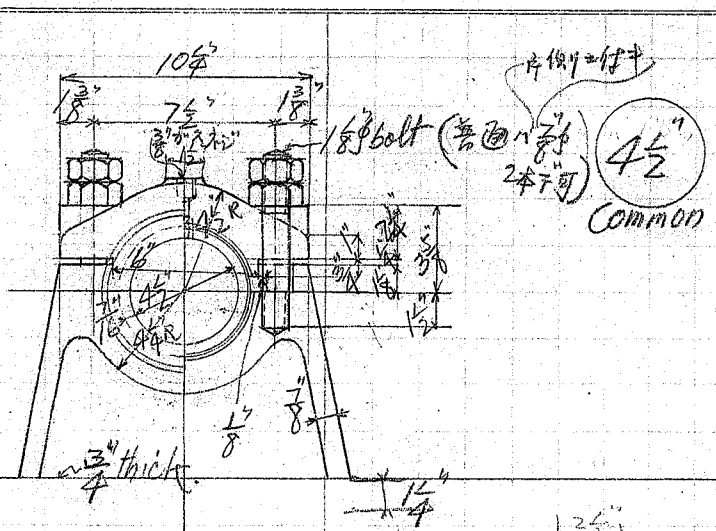

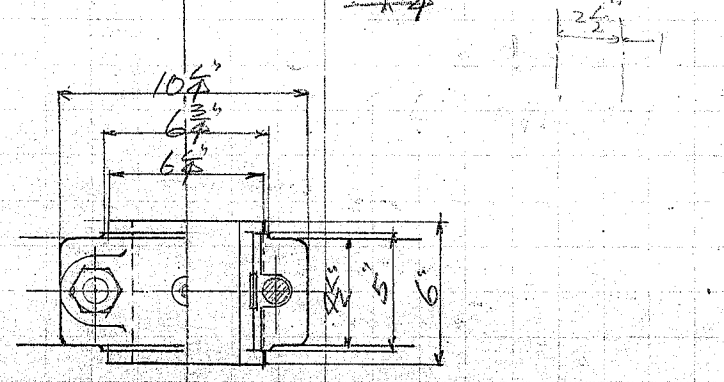

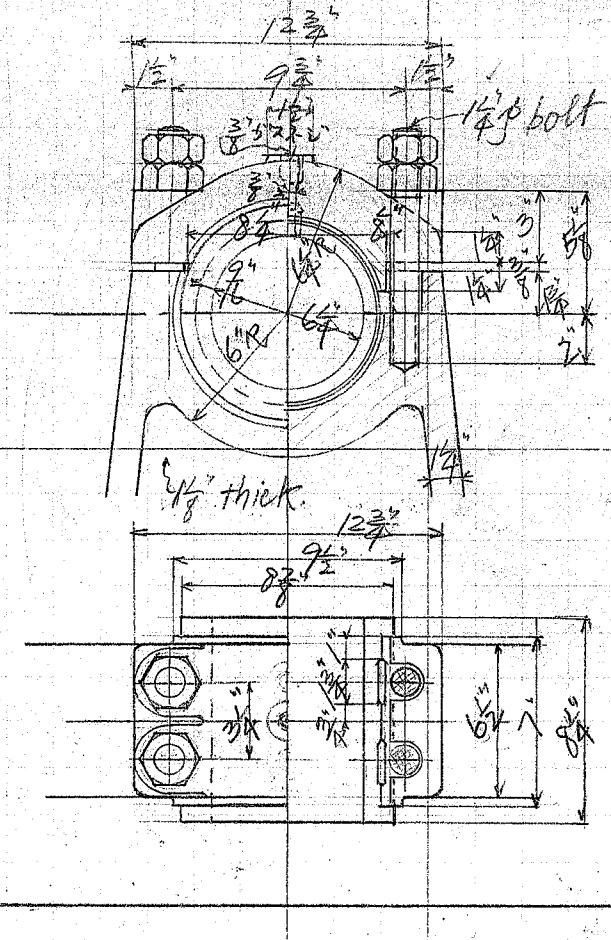

6¼"
普

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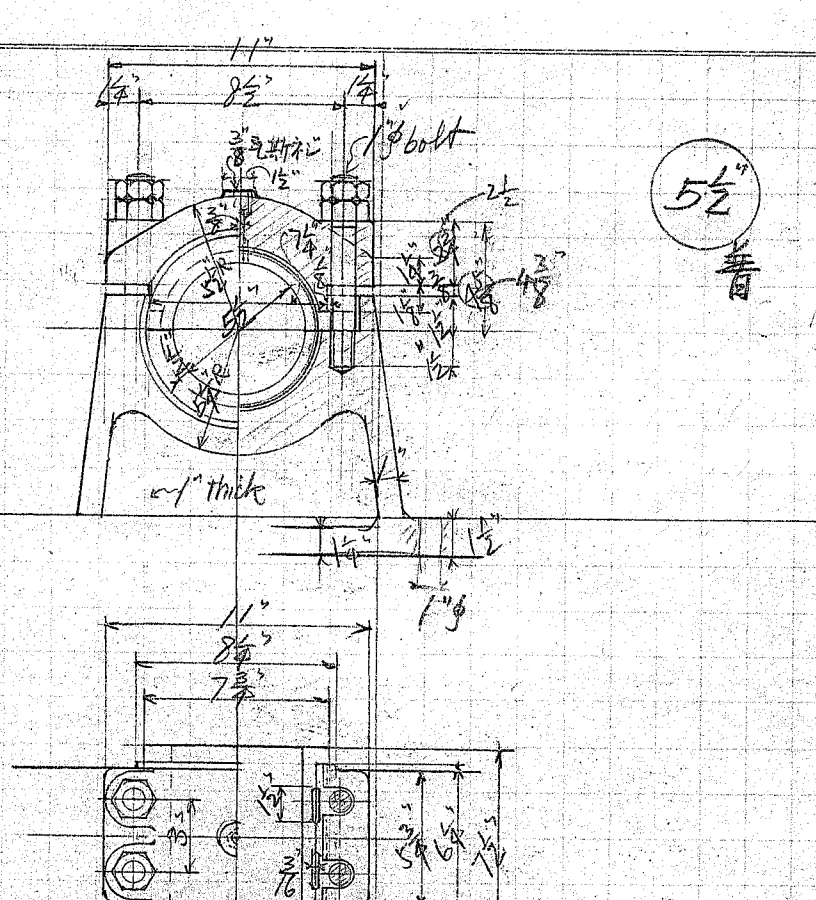
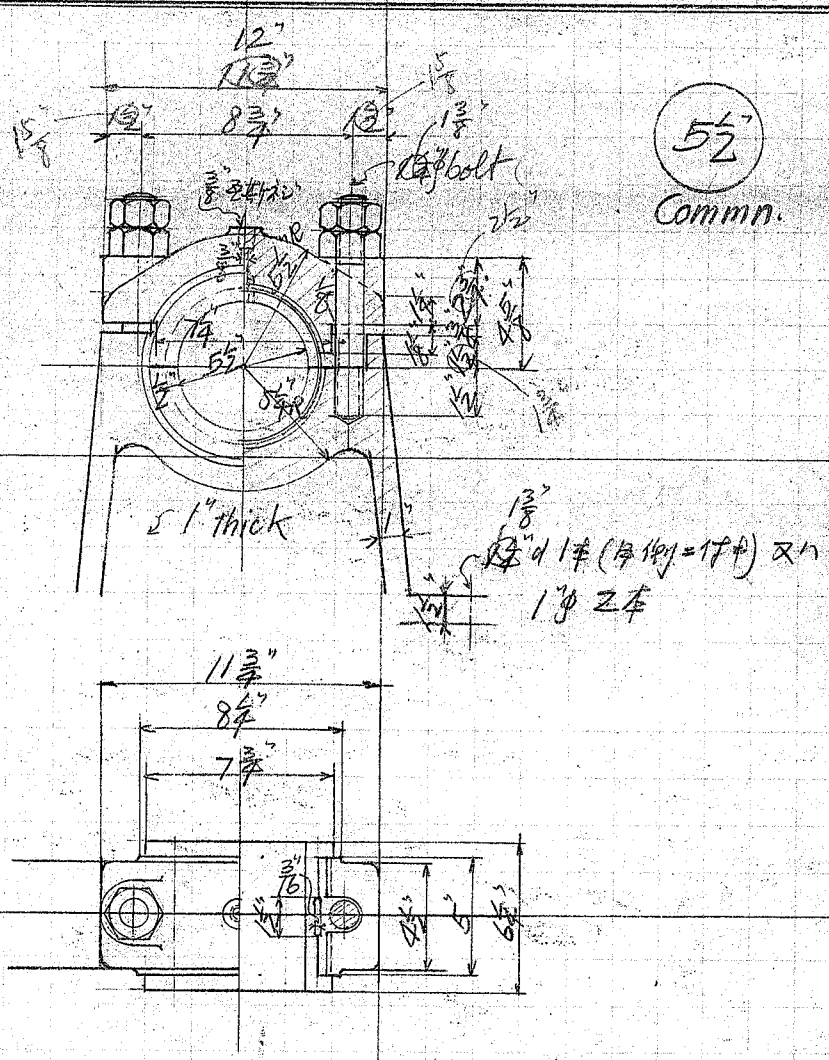


5½" 普



5½" Commn.

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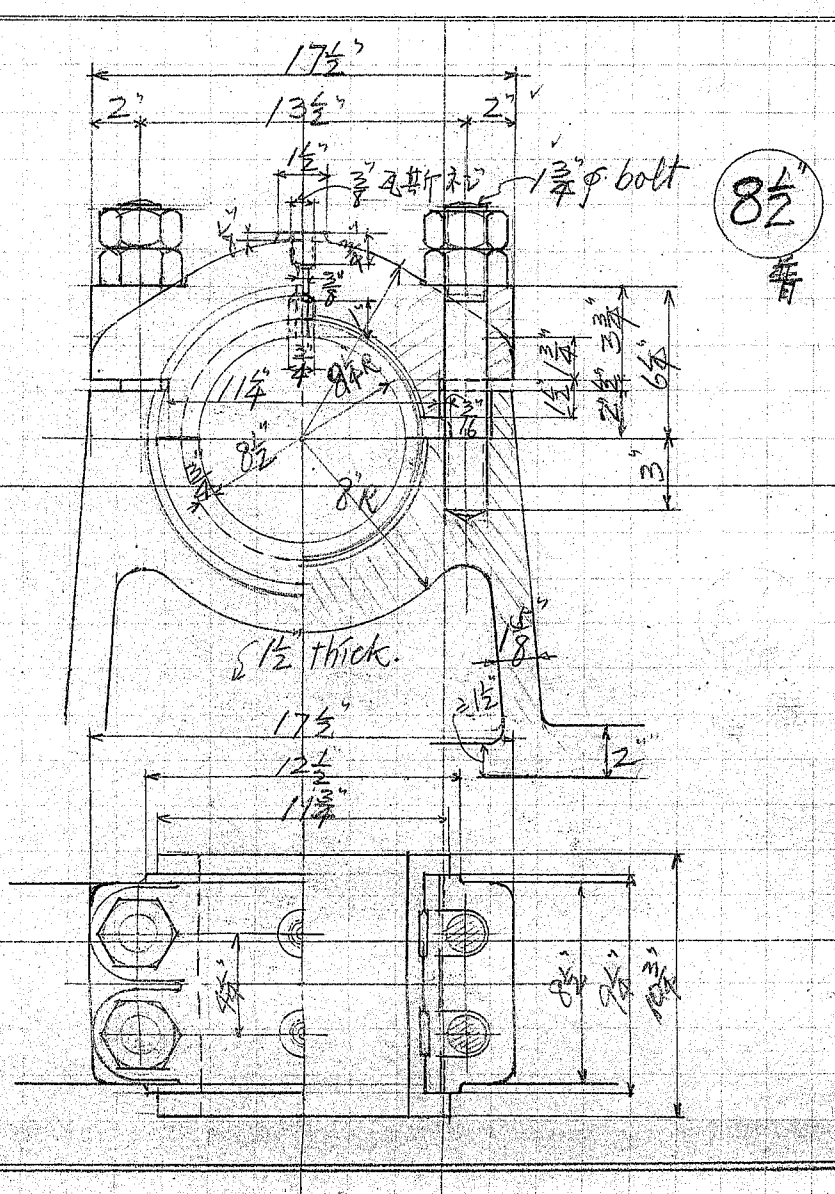
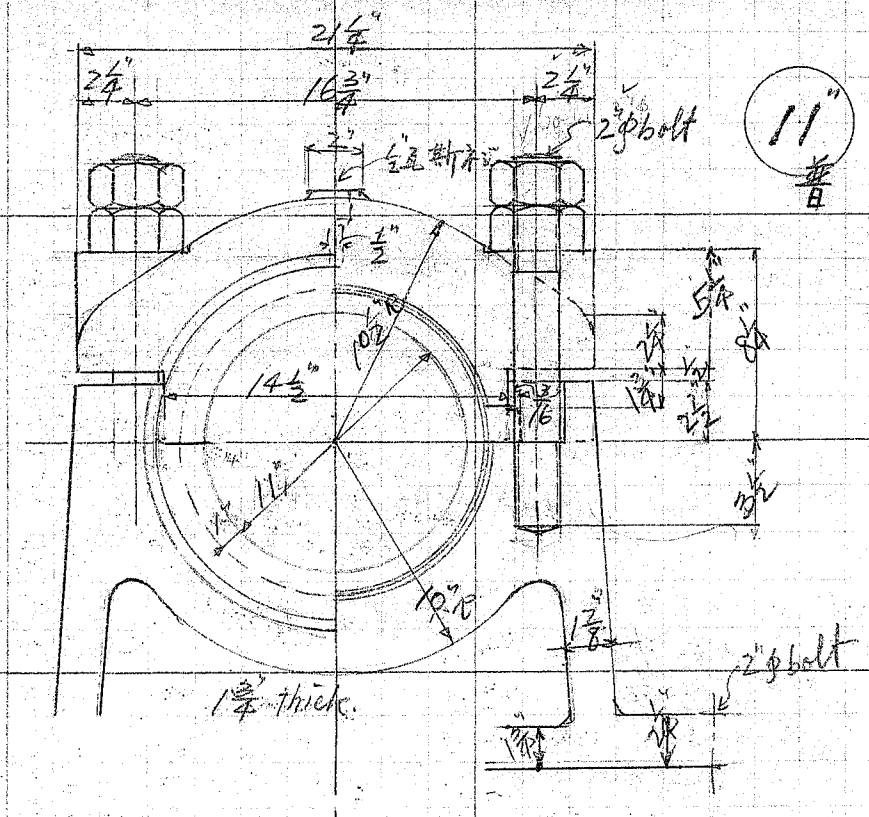
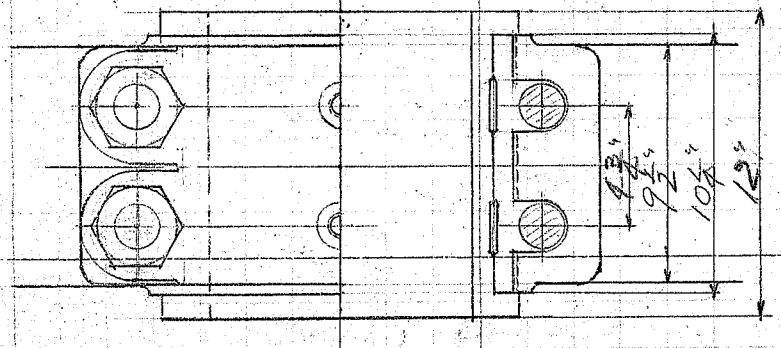
CALCULATIONS FOR





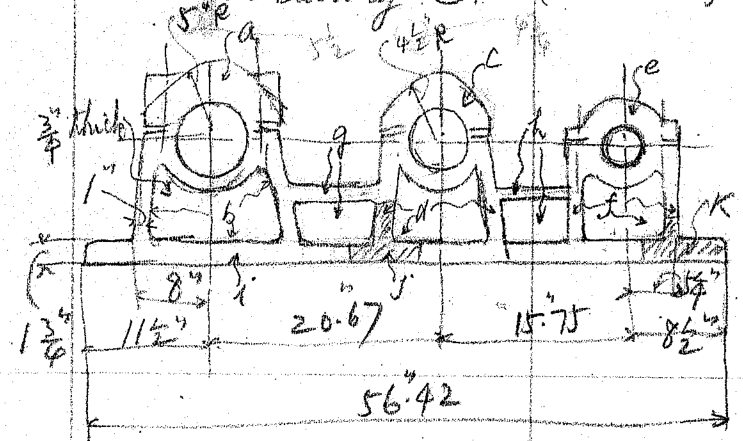


CALCULATIONS FOR 仮津橋

(B1)

BEARINGS

Common bearing B1 (Cast iron) for mortor, 1st & 2nd shaft 1 req'd



volume

a. (10"φ − 6"φ) × 5" × 2 = 500

b. {17.5 × 1 × 5 × 4 = 350; 12 × .75 × 10.5 × 2 = 190} = 1,040 cub. in.

c, d } = 765

e, f } = 630

g, h } = 175

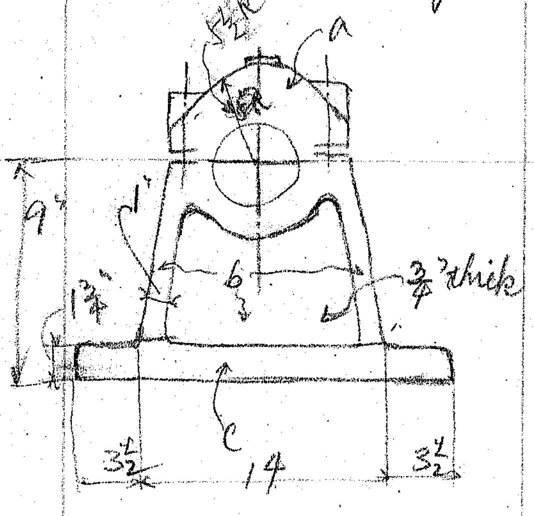
i = 1,200

j, k } = 600

total vol. 4,410 cub. in

w't .26 × 4410 = 1,150#

2nd shaft bearing B2 (Cast iron) 2 req'd.



a. = 250

b. {12 × 1 × 5.25 × 2 = 125; 11" × .75 × 3 = 250} 375

c 7 × 21 × 1.75 = 260

885 "³

w't .26 × 885 = 230#

for 2 block 230 × 2 = 460#

増田淳氏関係資料
(独立行政法人 土木研究所蔵)

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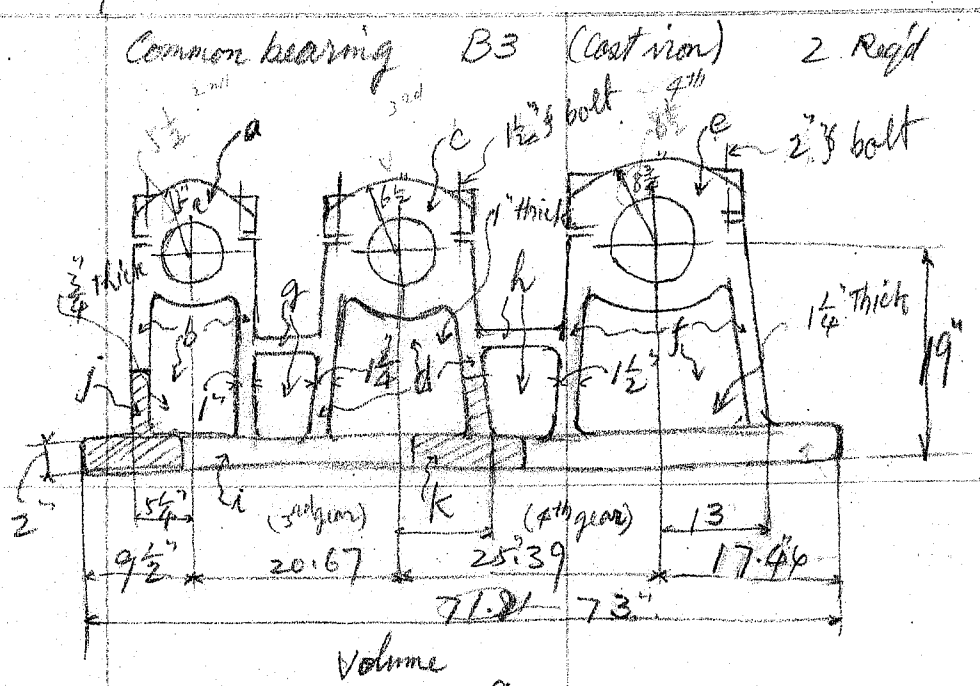
CALCULATIONS FOR

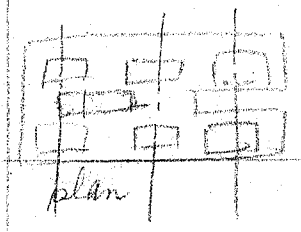
(B2)

Common bearing B3 (cast iron) 2 Reqd

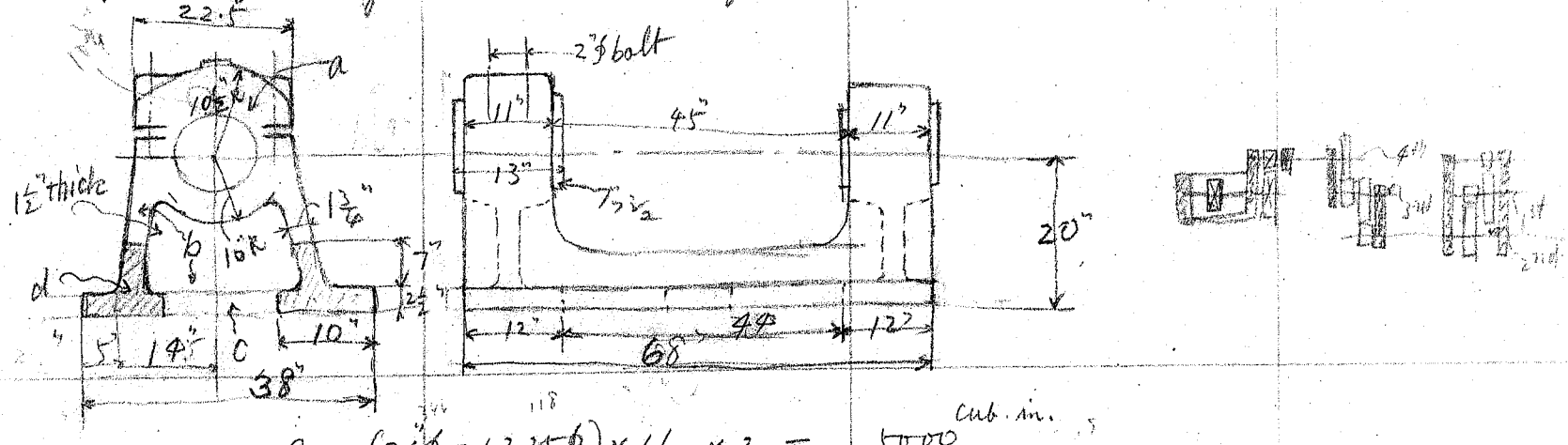


Volume

a.		= 500 "³
b.	22. × 5.25 × 1.0 × 4	= 460
	8.25 × 13 × .75 × 2	= 160
c.	(13ϕ − 7.625ϕ) × 7½" × 2	= 1,300
d.	7.5 × 23 × .125 × 4	= 860
	15 × 12.5 × .1 × 2	= 375
e	(17.5ϕ − 10.25ϕ) × 9.25 × 2	= 3,080
f.	9.5 × 15 × 26 × 4	= 1,480
	21 × 9 × .125 × 2	= 470
g, h	—	= 200
i	10 × 73 × 2 × 2	= 2920
j, k	—	= 700
total vol.		12,505 "³
wt of 1	.263 × 12,505 =	3300 #
of 2 =	3,300 × 2 =	------ 6600 #



main pinion bearing (Cast iron) 2 Reqd.



a.	(21ϕ − 12.25ϕ) × 11 × 2 =	5,000 cub. in.
b.	11 × 29 × 1.75 × 4	= 2,230
	22 × 10 × 1.5 × 2	= 660
c	12 × 25 × 2 × 38	= 2280

d {10 × 2.5 × 44 × 2 = 2,200
{7 × 1.75 × 44 × 2 = 1080
中心 10 × " × 18 × 1 = 315

13,765 cub. in.

wt of 1 .263 × 13,765 = 3,620
" of 2 7,240#

total wt of Bearings — 15,450#

HAND BRAKE (Cast iron ½ 砂鋼 ½ 位c) - 1,100

GEA COVERS 450

Summary of Machinery part. (except trunnion & its bearings)

Gears	38320#
shafts	6,870
shaft coupling	330
clutchs	500
Bearings	15,450
Hand brake	1,100
Gear cover	450
Anchors (bolts & e.t.c.)	5,800
air buffers (front & rear. 4 reqd)	4,700
Locking & Gate (front)	5,000
Gate (Rear)	3,000
Indicator	200
	81,720# or 36.5 tons

(12,700 or 5.7 tons)

上記計算ハ多少内輪ニ見積ッテアル故ニ 1.5割ヲ加ヘトス (36.5 × 1.15 = 42 tons)
見当ナリ

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CALCULATIONS FOR

仮閘橋

SHAFT

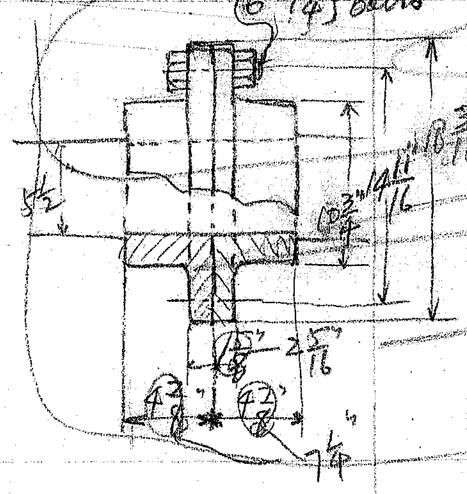
1. 軟鋼

motor shaft	1 − 3½φ × 10'0	32.71# × 10. = 327.#
1st "	1 − 4½φ (4¾") × 2'3	54.07 (60.25) × 2.3 = 125 139
2nd	1 − 5¼φ (5½") × 26'5	73.6 (80.78) × 26.5 = 1950 2140

2. 半硬鋼

3rd shaft	2 − 6½φ × 3'5	112.82 × 3.5 × 2 = 990.
4th "	2 − 8¾φ (8½") × 8'5	204.45 (192.93) × 8.5 × 2 = 3478 3274
		6,870# or 3.06 tons

SHAFT COUPLING. (Cast iron) 2 sets req'd. 神戸 全一、但シ長サノ短キスムット(長サ7¼")



vol. (13.125φ − 7.125φ) × 3.25 = 309 in³ @400 × 2 = 800#

(7.125φ − 3.5φ) × 9.75 = 296

605

wt .263 × 605 = 159#

4 bolts @1.8 × 4 = 7

166#

2 sets 166 × 2 = 332#

CLUTCH (軟鋼) - - - - - - - - - - - - - - 500#

7854

×4 = 3.142 ÷ 6,

= .523

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CALCULATIONS FOR

吊橋 (Bascule Bridge)

機械重量計算.

GEARS

1st Gear;—
Motor pinion 1 reqd @ 85# = 85#
spur wheel 1 @ 300 = 300

2nd Gear;—
pinion 1 @ 155 = 155
spur wheel 1 @ 550 = 550

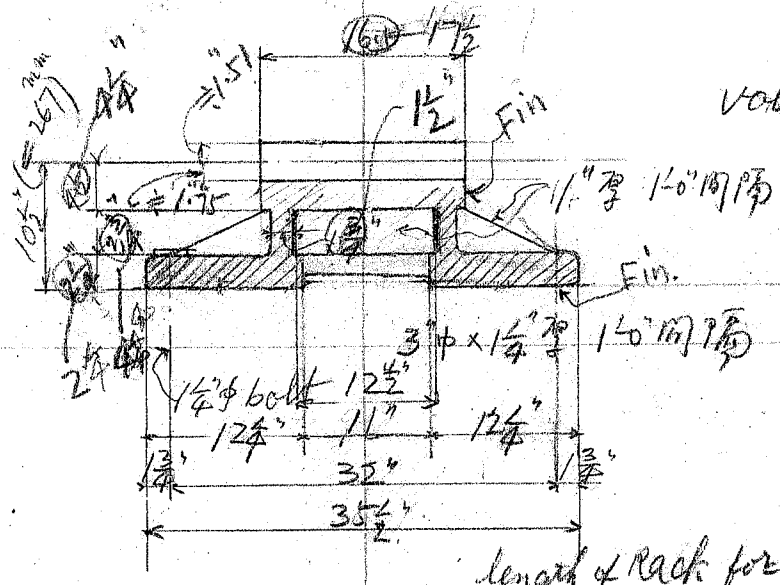
3rd Gear;—
pinion 2 @ 155 = 310
spur wheel 2 @ 600 = 1200

4th Gear;—
pinion 2 @ 135×8.5×.283 = 245# = 490
spur wheel 2 @ 1,100 = 2200

5th Gear;—
pinion 2 @ (219×11×.283 = 683 req 490#) = 980#
spur wheel 2 @ 2200# = 4,400#

main pinion 2 reqd
(22.75×17 + 11¢×36 + 13¢×24 = 405×17 + 95×36 + 132.5×30
= 6,880 + 3,420 + 3,980 = 14,280 cub. in. ×.283 = 4,040#)
4040×2 = 8,080#

Rack (machine cut) 2 reqd Cast steel.



Volume per 12" cub. in.
16.5×4.5 × 12 = 890
1.75×3.75×2×12 = 158
2¼×12.25×2×12 = 662
1.25×1.0×3.75 = 47
8×3.75×1.0 = 30
3×1.25×11 = 38
1,825

wt .283×1,825 = 515#/ft

length of Rack for 1 girder = 19 ft wt = 515×19 = 9,785#

wt for 2 girder 9,785×2 = 19,570# or 8.74 tons

Summary of Gear = 38,320# or 17.10 tons

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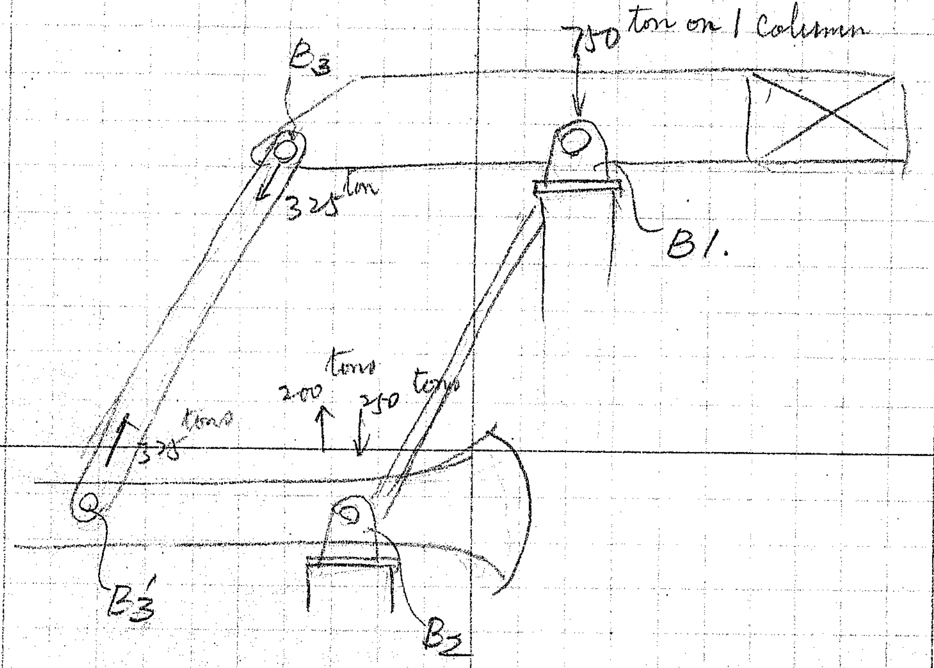
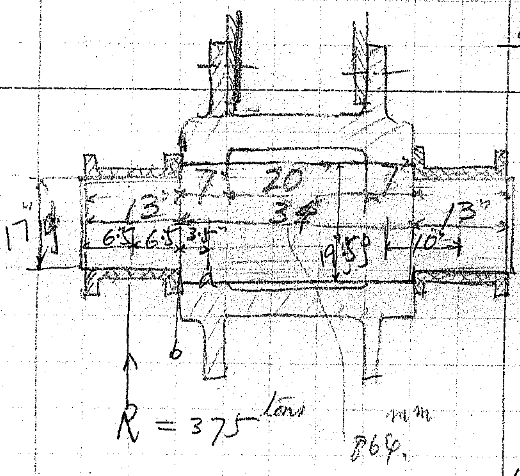
CALCULATIONS FOR

液圧式 バスキュール (リンク式)



1. Trunnion at B1.



at a.

$M_b = 375 \times 2{,}240 \times 10 = 8{,}400{,}000$ "#

$M_t = 375 \times 2{,}240 \times .15 \times 8 = 1{,}010{,}000$ "#

$M_e \doteqdot 17{,}000{,}000$ "#

$d_a \doteqdot 1.72 \sqrt[3]{\dfrac{17{,}000{,}000}{13{,}000}} = 1.72 \times 11 = \underline{18.9}$" say $19\frac{1}{2}$"φ

at b

$M_b = 375 \times 2{,}240 \times 6.5 = 5{,}460{,}000$ "#

$M_t = \quad = 1{,}010{,}000$

$M_e \doteqdot 13{,}000{,}000$ "#

$d_b \doteqdot 1.72 \sqrt[3]{\dfrac{13{,}000{,}000}{13{,}000}} = 1.72 \times 9.733 = 16.75$"φ say 17"φ

Unit bearing pressure.

at a $p = \dfrac{375 \times 2240}{19 \times 7} = 6{,}320$ #/□" ok

on bearing $p = \dfrac{375 \times 2240}{17 \times 13} = 3{,}800$ #/□" ok

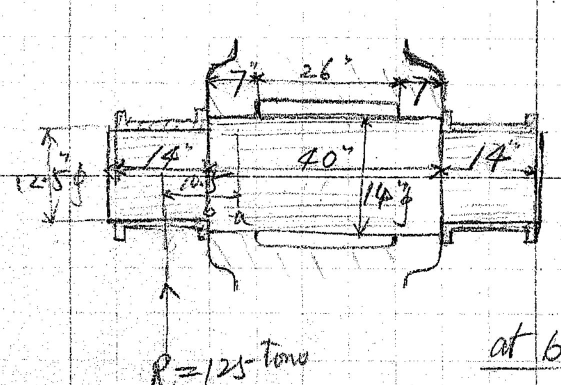
2. Trunnion at B2

at a

$M_b = 125 \times 2{,}240 \times 10.5 = 2{,}940{,}000$ "#

$M_t = 125 \times 2240 \times .15 \times 7 = 294{,}000$ "#

$M_e \doteqdot 6{,}500{,}000$ "#



$d_a \doteqdot 1.72 \sqrt[3]{\dfrac{6{,}500{,}000}{13{,}000}} = 1.72 \times 7.937 = 13.64$" say 14"φ

at b. $M_b = 125 \times 2240 \times 7 = 1{,}960{,}000$ "#

$M_t = \text{〃} \quad \text{〃} \times .15 \times 6 = 252{,}000$

$M_e \doteqdot 4{,}500{,}000$

$d_b \doteqdot 1.72 \sqrt[3]{\dfrac{4{,}500{,}000}{13{,}000}} = 1.72 \times 7.02 = 12.06$" say $12\frac{1}{2}$"φ

Unit bearing pressure
at a $p = \dfrac{125 \times 2240}{7 \times 14} = 2{,}860$ #/□"
on bearing $p = \dfrac{125 \times 2240}{12.5 \times 14} = 1{,}600$ #/□"

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CALCULATIONS FOR

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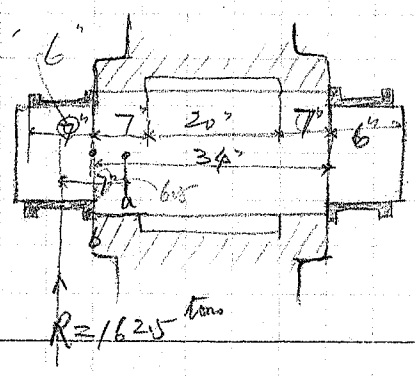
3. Torsion at B_3 & B_3'



at a

$M_b = 16.25 \times 2240 \times 7 = 2{,}550{,}000$ "#

$M_t = $ " " $\times 1.5 \times 6 = 330{,}000$

$M_e \doteqdot 5{,}300{,}000$ "#

$d_a \doteqdot 1.72 \sqrt[3]{\frac{5{,}300{,}000}{13{,}000}} = 1.72 \times 7.417 = 12.75$ say 13" ϕ

at b

$M_b = 16.25 \times 2260 \times 3.5 = 1{,}275{,}000$ "#

$M_t = 330{,}000$

$M_e \doteqdot 2{,}700{,}000$ "#

$d_b \doteqdot 1.72 \sqrt[3]{\frac{1{,}275{,}000}{13{,}000}} = 1.72 \times 4.64 = 7.9$ say 10" ϕ

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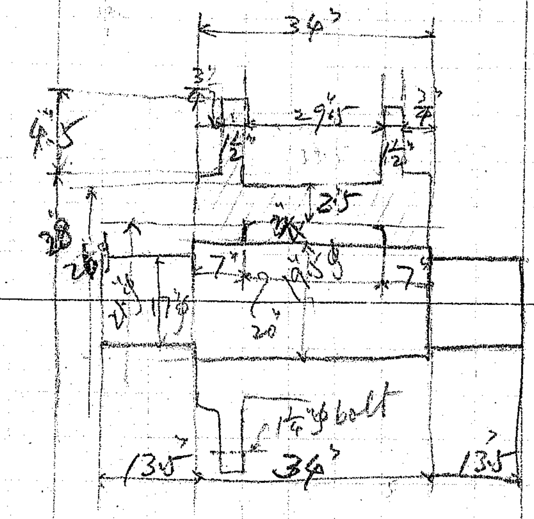
CALCULATIONS FOR

1.

trunnion & bearing at B1 (for 1 girder)



Trunnion. (半硬鋼)

17 φ × 13.5 × 2 = 226.98×27 = 6120 ''³

19.5 φ × 34 = 299. × 34 = 10,160

16,280

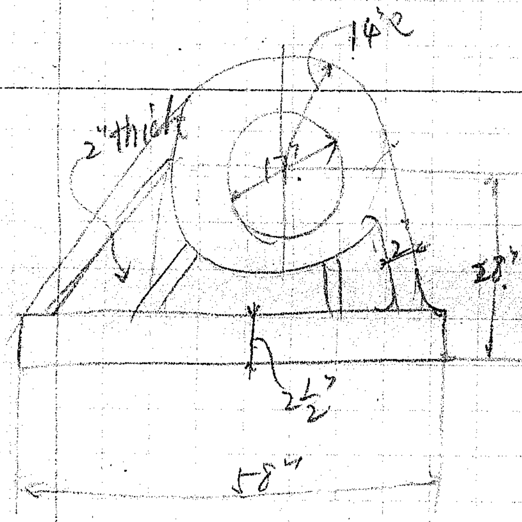
wt .283 × 16,280 = 4,620 #

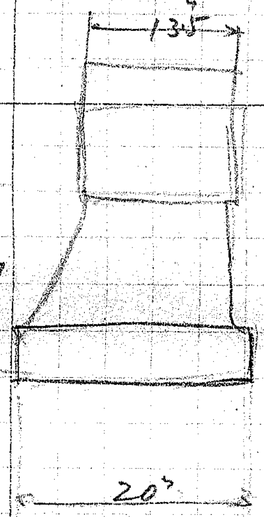
Boss. (28φ − 19.5φ) × 14 = 4438

(Cast steel) (26φ − 21.0φ) × 20 = 3.700

(37φ − 28φ) × 3 = 1.377

9,515 × .283 = 2,693 #





Bearings (Cast steel) (2 Reqd)

(28"φ − 17"φ) × 13.5 = 5,252

17 × 2 × (28 + 28 + 26) = 3,128

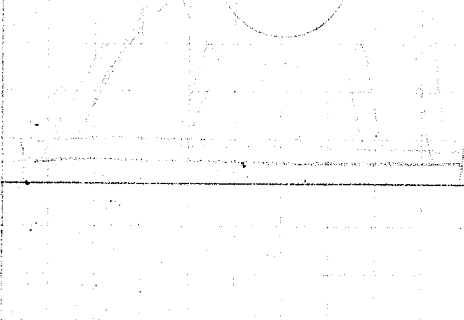
40 × 10 × 2 = 800

58 × 20 × 2.5 = 2,900

12,080 @ .283 = 3420 #

× 2

6,840 #



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CALCULATIONS FOR

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Σ. Trunnion & Bearing.

Trunnion (鍛鋼) 1 Reqd

12.5φ × 28 = 3,444

14φ × 60 = 6,160

9604 × .283 = 2,718#

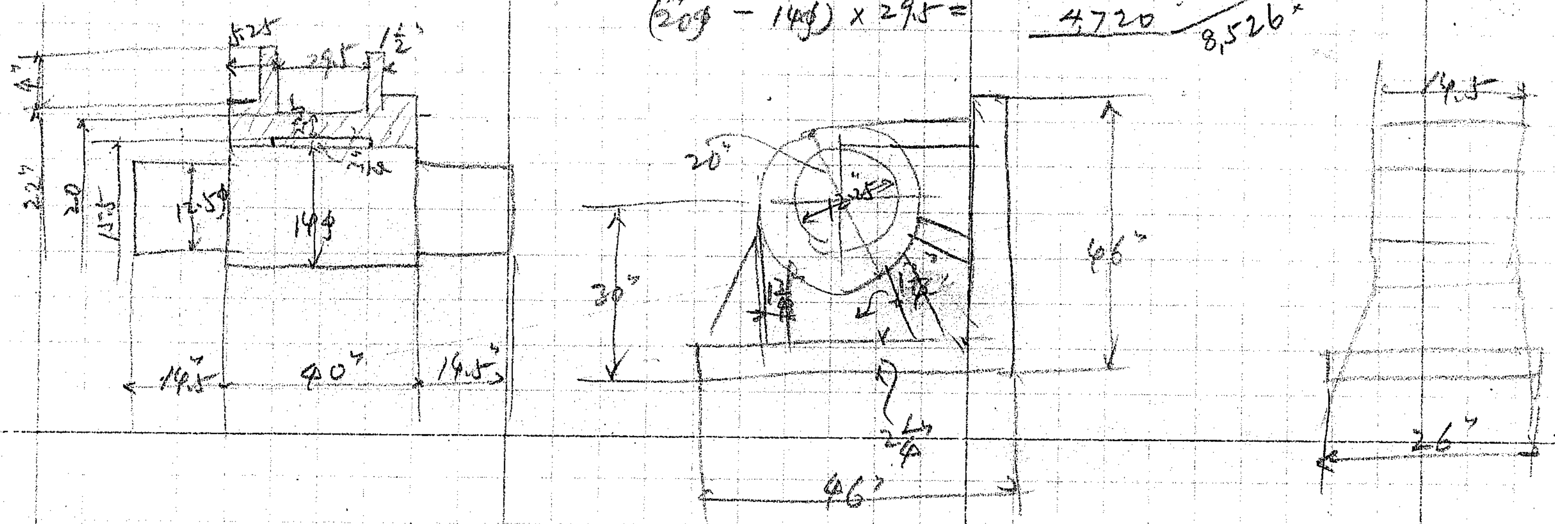
Boss. (Cast steel) 1 Reqd

(22φ − 14φ) × 12.5 = 2,825

(30φ − 22φ) × 3. = 981

(20φ − 14φ) × 29.5 = 4720

8,526 × .283 = 2,413#



Bearing. (Cast steel) 2 Reqd

(20φ − 12.25φ) × 14.5 = 2,842

46 × 26 × 2.25 × 2 = 5,382

15 × 1.75 × 120 = 3,150

40 × 20 × 1.75 = 1,400

22 × " × 4 = 770

13,544 × .283 = 3,840#

× 2

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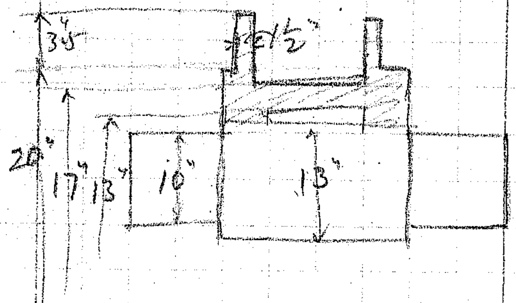
CALCULATIONS FOR

3. at B3.



Trunnion ; — ([illegible])

10"φ × 13 = 1,030 ✓

13φ × 34 = 4,530 ✓

5,560 in^3 × .283 = 1,570# ✓

Boss of girder (cast steel)

(27φ − 20φ) × 3 = 780 ✓

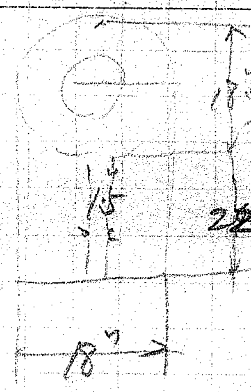
(20φ − 13φ) × 14 = 2540 ✓

(17φ − 13φ) × 20 = 1880 ✓

5200 × .283 = 1,470# ✓

Boss of Link

(18φ − 10φ) × 12 = 2100 ✓



18 × 1.5 × 24 = 650 ✓

20 × 1.5 × 22 = 660 ✓

3410 × .283 = 965# ✓

× 2 req'd

1,930.# ✓

(新)

220V 60 cycle

2-100 HP

CALCULATIONS FOR

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牧港橋 バスキュール 機械装置 見積設計

Horse power required

Operating time: acceleration 10 sec.
uniform speed 70
returdation 20
100 sec. or 1 min. 40 sec.

Rack radius = 4.3 m = 14.107' = 169.3" Bridge opene = 72°

length of rack circle = $\pi \times 4.3 \times \frac{72}{180} = 5.40^m = 17.72$ ft

gear efficiency = $(.94)^6 = 69\%$

HP required for 1# force on Rack circle = $\frac{17.72}{33000 \times .69} \times \frac{60}{85} = .000549$ HP

wind load. # 19.6 m = 64.3' to 33.3 m = 109' area = 64.3 × 109 = 7010 □'

m't = $7010 \times 10^{\#} \times 58.4 = 4{,}100{,}000$ '#

Rack force = $\frac{4{,}100{,}000}{14.107} = 290{,}000^{\#}$ for 10#/□' wind
320,000 " 11 "
350,000 " 12 "

Force at Rack circle:— load on trunnion = 1050 Tons = 2,300,000#

due to frictional resistance $2{,}300{,}000 \times .15 \times \frac{8}{169.3} = 16{,}300$
" eccentric load " $\times \frac{2}{169.3} = 27{,}200$
43,500#
" wind load for 10#/□' = 290,000
333,500#

Required HP = 333,500 × .000549 = 183 HP for 10#/□' wind
363,500 × " = 200 HP " 11 "
393,500 × " = 216 HP " 12 "

Use Motor 2-100 HP = 200 HP 558 r.p.m. (assumed) 220V. 60 cycle A.C induction motor

N.R of main pinion for 72° of Rack circle = $\frac{17.72 \times 12}{22.68 \times \pi} = 2.984$

∴ N.R.M = $2.984 \times \frac{60}{85} = 2.106$

Total gear ratio = $\frac{558}{2.106} = 265$ use $(\frac{47}{15})^4 \times \frac{43}{16} = \frac{4879681}{50625} \times \frac{43}{16} = 265$ OK

6 sets gears (from motor pinion to Rack)

1st Gear (15° involute teeth)

motor pinion:—

no of teeth $N = 15$
diametral pitch $P_d = 1\frac{3}{4}$
pitch dia. $d = 8.571"$ min. shaft 4.36" φ
circular pitch $p = 1.7952"$
face of tooth $f = ~~5.75~~$ 6"

load on tooth $W = \frac{200 \times 33000 \times 12}{\pi \times 8.571 \times 558} = 5{,}270^{\#}$

constant $y = .075$

speed of tooth $s = 8.571 \times \pi \times 558 \div 12 = 1250$ ft per min.

$S = \frac{5270}{1.7952 \times 5.75 (6.00) \times .075} = 6{,}520$ #/□" < 7,500 OK

Spur wheel:—

$N = 43$
$f = ~~5.75~~$ 5½"
$d = 24.571"$

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(独立行政法人 土木研究所蔵)

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CALCULATIONS FOR

2^{nd} gear (15° involute teeth)

pinion ;—

$N = 15$

$P_d = 1\frac{1}{2}$

$d = 10''$

$p = 2.0944''$

$f = 6\frac{1}{2}''$

max. shaft = 5.1'' φ

$W = 5270 \times \frac{24.571}{10} \times .94 = 12{,}160^{\#}$

$v = 10 \times \pi \times \frac{558 \times 15}{43 \times 12} = 510$ ft per min.

$S = \frac{12160}{2.0944 \times 6.5 \times .075} = 17{,}900^{\#}/\square'' < 14{,}000$ Ok

spurwheel ;—

$N = 47$

$f = 6''$

$d = 31.333''$ (= 797 mm)

3^{rd} gear (15° involute teeth)

pinion :— (2^{nd} gear ノ spurwheel ヲ 軸ノ中央ニ置キ、ソノ shaft ヲ左右ニ引キテ 3^{rd} gear ヲ両方ニ設ケル)

$N = 16$

$P_d = 1\frac{1}{2}$

$d = 10.667''$

$p = 2.0944$

$f = 6\frac{1}{2}''$

max. shaft 5.62''

$y = .077$

$W = \frac{12160 \times 31.333}{2 \times 10.667} \times .94 = 16{,}780^{\#}$

$v = 510 \times \frac{10}{31.333} = 162$ ft per min.

$S = \frac{16780}{2.0944 \times 6.5 \times .077} = 15{,}800^{\#}/\square'' < 20{,}000$ Ok

Spur wheel ;—

$N = 47$

$f = 6''$

$d = 31.333''$

4^{th} gear (15° involute teeth)

pinion ;—

$N = 15$

$p = 2\frac{3}{4}''$

$d = 13.130''$ (= 333 mm)

max. shaft 6.8'' φ

$f = 8\frac{1}{2}''$

$W = 16{,}780 \times \frac{31.333}{13.130} \times .94 = 37{,}600^{\#}$

$S = \frac{37600}{2.75 \times 8.5 \times .075} = 21{,}500^{\#}/\square'' < 25{,}000$ ok

Spur wheel ;—

$N = 47$

$f = 8''$

$d = 41.141''$

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CALCULATIONS FOR

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5th gear (20° involute teeth)

pinion :—

$N = 15$
$p = 3\frac{1}{2}$"
$d = 16.711$ (=425 mm)
$f = 11$"

max. shaft 9.0

$W = 37{,}600 \times \frac{41.141}{16.711} \times .94 = 87{,}000$ #

$y = .092$

$S = \frac{87000}{3.5 \times 11 \times .092} = 24{,}550$ #/□" < 26,000 ok

Spur wheel :—

$N = 47$
$f = 10\frac{1}{2}$"
$d = 52.362$
$y = .128$

$S = \frac{87{,}000 \times .94}{3.5 \times 10.5 \times .128} = 17{,}400$ #/□" < 20,000 ok

Main pinion & Rack (6th gear) 20° involute teeth

main pinion :—

$N = 15$
$p = 4\frac{3}{4}$"
$f = 17\frac{1}{2}$
$y = .092$
$d = 22.68$ (=575 mm)

$W = 87{,}000 \times \frac{52.362}{22.68} \times .94 = 188{,}700$ #

$S = \frac{188{,}700}{4.75 \times 17.5 \times .092} = 24{,}700$ #/□" < 26,000 ok

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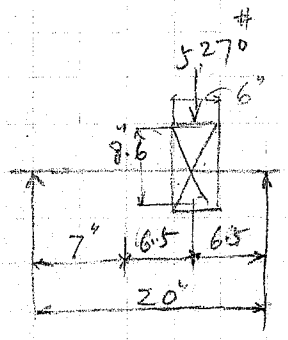
CALCULATIONS FOR

SHAFTS

motor shaft :— (軸受 3/3)



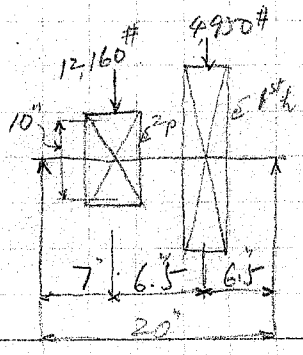
$M_b = \frac{5270 \times 6.5}{20} \times 13.5 = 23{,}100$ "#

$M_t = 5{,}270 \times 4.3 = 22{,}650$ "#

$M_e = 23{,}100 + \sqrt{23{,}100^2 + 22{,}680^2} = 55{,}450$ "#

$\therefore d = 1.72 \sqrt[3]{\frac{55{,}450}{9{,}000}} = 3.15$" say $3\frac{3}{4}$"φ

1st shaft :— (軸受 軸受)

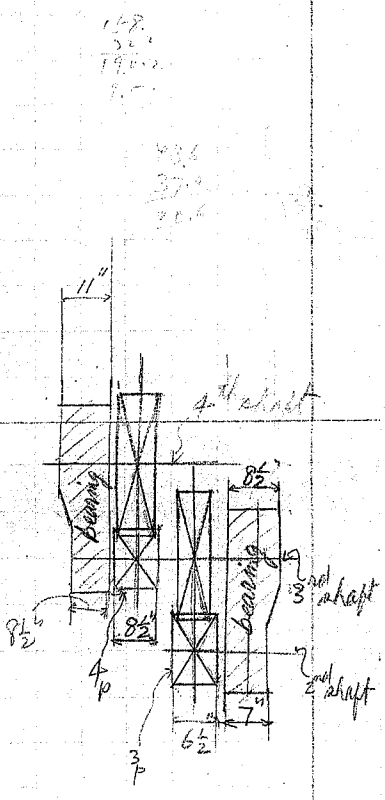


$M_b = \frac{12{,}160 \times 13 + 4{,}950 \times 6.5}{20} \times 7 = 66{,}000$ "#

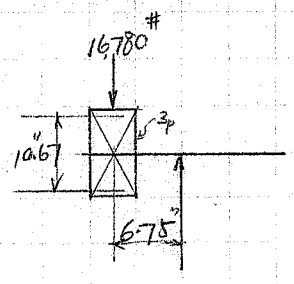
$M_t = 12{,}160 \times 5 = 60{,}800$ "#

$M_e = 66{,}000 + \sqrt{66{,}000^2 + 60{,}800^2} = 155{,}700$ "#

$\therefore d = 1.72 \sqrt[3]{\frac{155{,}700}{9{,}000}} = 4.45$" say $4\frac{3}{4}$"φ



2nd shaft :— (軸受 軸受)



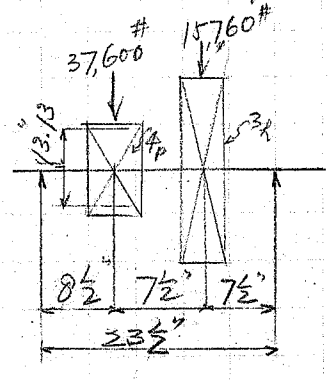
$M_b = 16{,}780 \times 6.75 = 113{,}200$ "#

$M_t = 16{,}780 \times 5.33 = 89{,}500$ "#

$M_e = 113{,}200 + \sqrt{113{,}200^2 + 89{,}500^2} = 257{,}200$ "#

$\therefore d = 1.72 \sqrt[3]{\frac{257{,}200}{9{,}000}} = 5.26$ say $5\frac{1}{2}$"φ

3rd shaft :— (軸受 軸受)



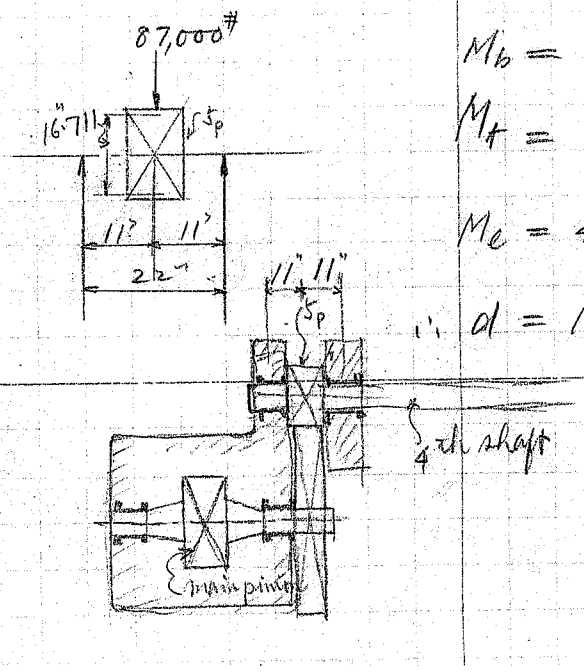
$M_b = \frac{37{,}600 \times 15 + 15{,}760 \times 7.5}{23.5} \times 8.5 = 247{,}000$ "#

$M_t = 37{,}600 \times 6.565 = 246{,}500$ "#

$M_e = 247{,}000 + \sqrt{247{,}000^2 + 246{,}500^2} = 596{,}000$ "#

$\therefore d = 1.72 \sqrt[3]{\frac{596{,}000}{12{,}000}} = 6.32$" say $6\frac{1}{2}$"φ

4th shaft :— (軸受 軸受)



$M_b = 87{,}000 \times \frac{1}{2} \times 11 = 479{,}500$

$M_t = 87{,}000 \times 8.356 = 827{,}000$

$M_e = 479{,}500 + \sqrt{479{,}500^2 + 827{,}000^2} = 1{,}435{,}500$ "#

$\therefore d = 1.72 \sqrt[3]{\frac{1{,}435{,}500}{13{,}000}} = 8.24$" say $8\frac{1}{2}$"φ

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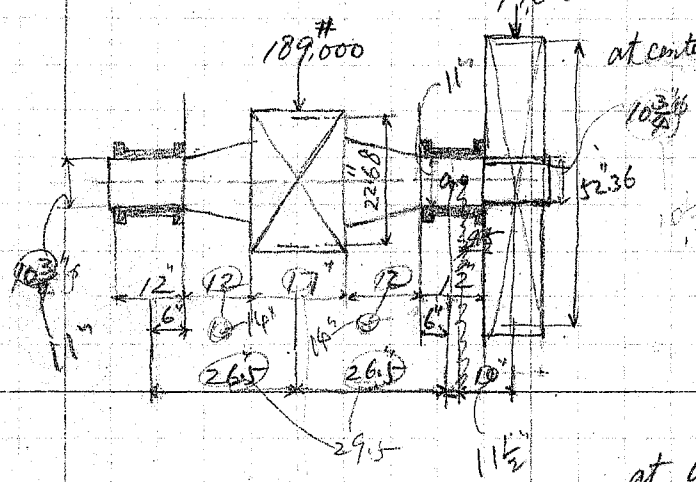
CALCULATIONS FOR

main pinion shaft — (半又鋼)



$M_b = \frac{189,000}{2} \times 26.5 = 2,635,000$ "#

$M_t = 189,000 \times 11.34 = 2,145,000$ "#

$Me = 2,635,000 + \sqrt{2,635,000^2 + 2,145,000^2} = 6,220,000$ "#

$d = 1.72\sqrt[3]{\frac{6,220,000}{13,000}} = 13.''4$ at center of main pinion

at a.

$M_b = 79,600 \times 11.5 = 916,000$ "#

$M_t = \quad \times 26.18 = 2,082,000$ "#

$Me = 916,000 + \sqrt{916,000^2 + 2,082,000^2} = 3,211,000$ "#

$d = 1.72\sqrt[3]{\frac{3,211,000}{13,000}} = 10.''78$ say $10\frac{3}{4}''\phi$

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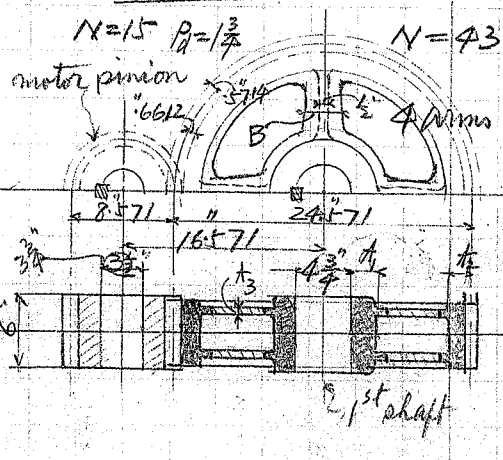
CALCULATIONS FOR

後伸塔

GEAR. (pinion は丸ラ半及鋼. spur wheel は鋳鋼. 何れも歯切り歯トス)

1st Gear (15° involut teeth) 1 set reqd



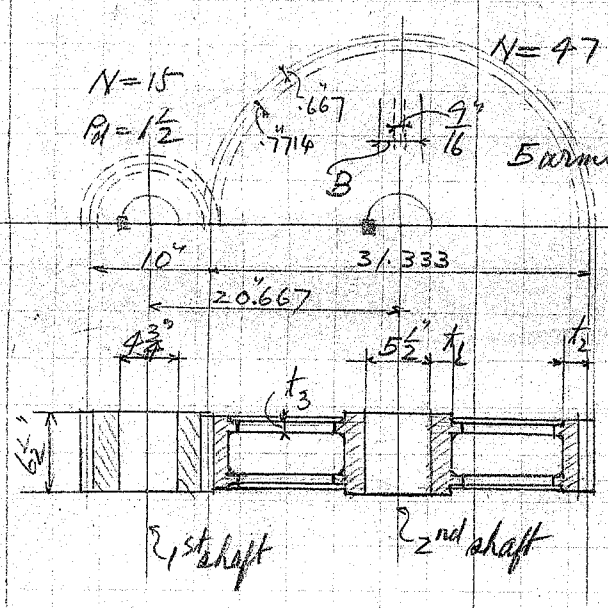
$t_1 = \frac{\sqrt[3]{515 \times 1.8 \times 12.3}}{3} = 1.65$ " say $1\frac{3}{4}$"

$t_2 = .47 \times 1.8 + .66 = 1.505$ " say $1\frac{5}{8}$"

$t_3 = .43$ " say $\frac{1}{2}$"

$B = \sqrt{\frac{515 \times 12.3}{4}} = 4.11$ "

2nd Gear (15° involute teeth) 1 set reqd.



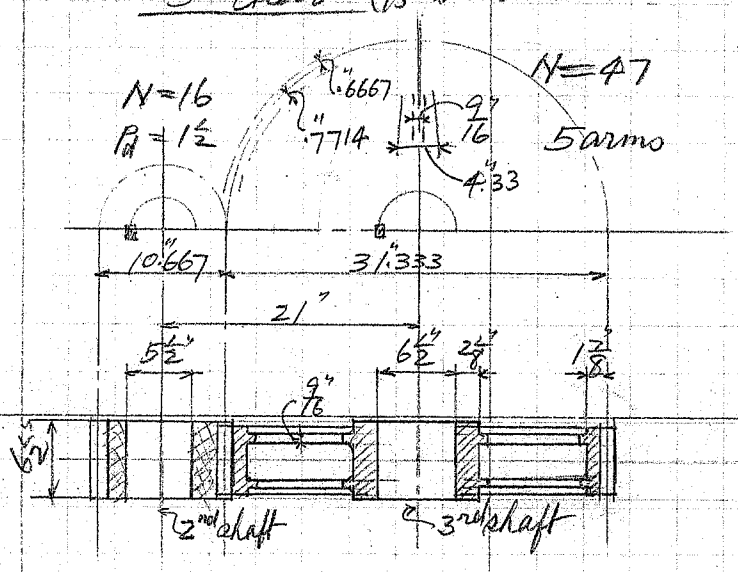
$t_1 = \frac{\sqrt[3]{6 \times 2.09 \times 15.67}}{3} = 1.935$ " say $2\frac{1}{8}$"

$t_2 = .47 \times 2.09 + .771 = 1.754$ " " $1\frac{7}{8}$"

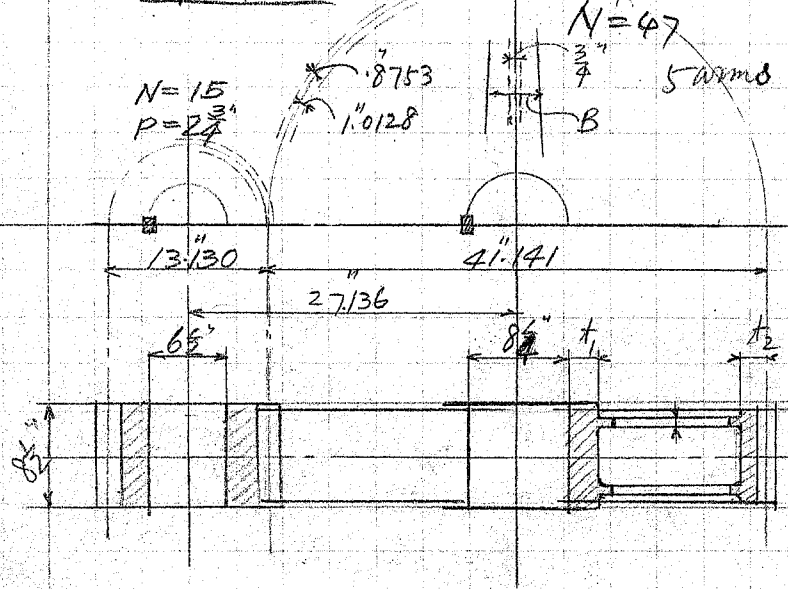
$t_3 = .5$ " " $\frac{9}{16}$"

$B = \sqrt{\frac{6 \times 15.67}{5}} = 4.33$ "

3rd Gear (15° involute teeth) 2 sets reqd.



4th Gear (15° involute teeth) 2 sets reqd.



$t_1 = \frac{\sqrt[3]{8 \times 2.75 \times 20.571}}{3} = 2.58$ " say $2\frac{5}{8}$"

$t_2 = .47 \times 2.75 + 1.013 = 2.31$ " " $2\frac{1}{2}$"

$t_3 = .66$ " " $\frac{3}{4}$"

$B = \sqrt{\frac{8 \times 20.571}{5}} = 5.73$ " " $5\frac{3}{4}$"

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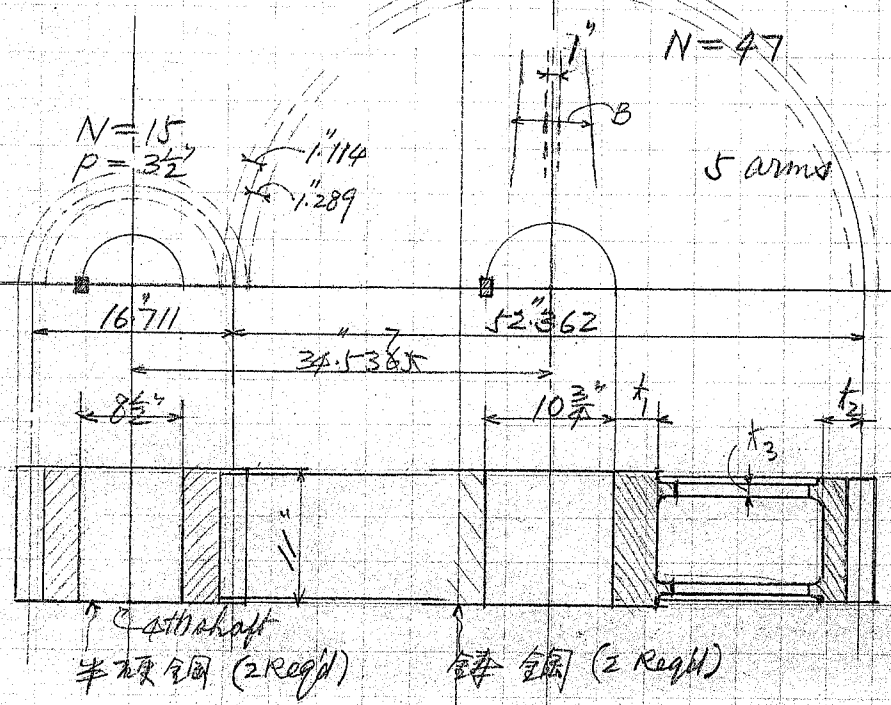
CALCULATIONS FOR

5th Gear (20° involute teeth) 2 sets regd



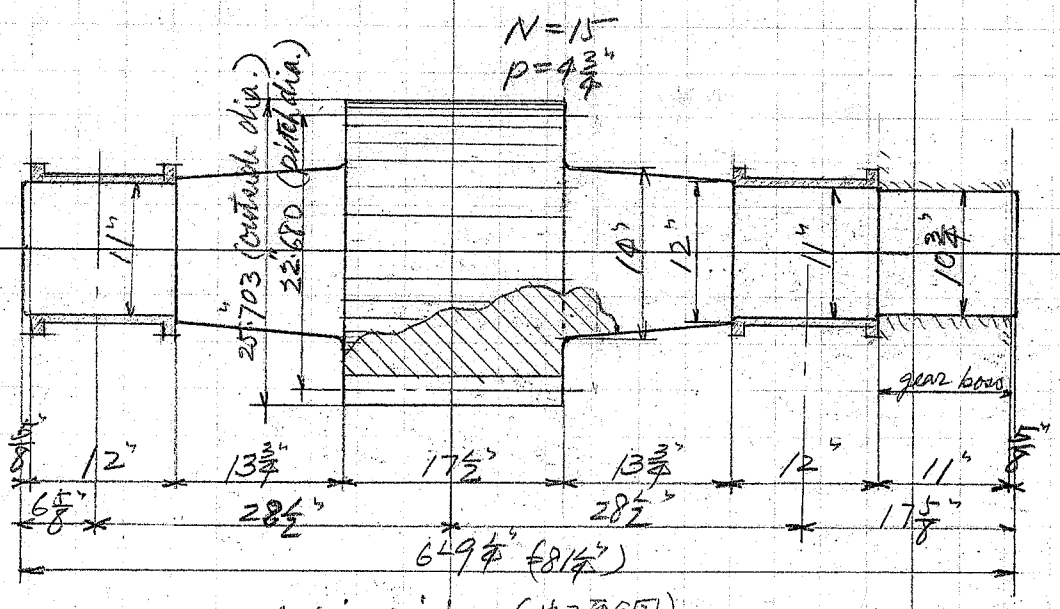
$t_1 = \frac{\sqrt[3]{105 \times 35 \times 26.181}}{3} = 3.29$ say $3\frac{1}{2}$"

$t_2 = 3.5 \times .47 + 1.289 = 2.939$ " 3^{5}

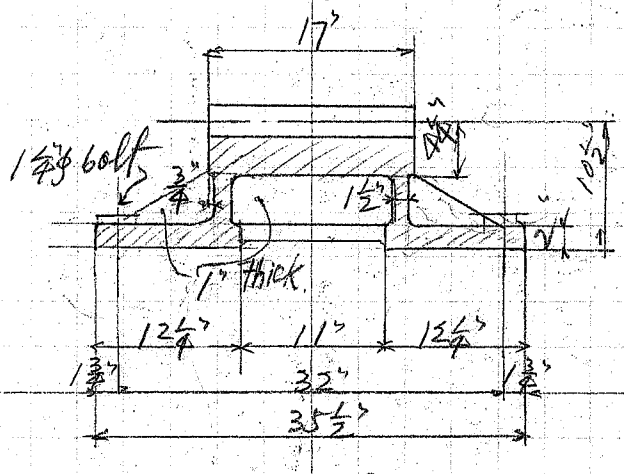
$t_3 = .84$ " 1"

$B = \sqrt{\frac{10.5 \times 26.181}{5}} = 7.4$ " ½"

Main pinion & Rack (20° involute teeth) 2 sets regd



main pinion (半硬鋼)



Rack (鋳鋼)

新
2-120 HP

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CALCULATIONS FOR
波止場ベスキュール機械装置見積設計

Horse power required
Operating time — acceleration 10 sec.
uniform speed 70
returdation 20
100 sec or 1 min. 40 sec

Rack radius = 4.3 m = 14.107' = 169.3" Brigde open = 72°
length of rack circle (in 72°) = π × 4.3 × 72/180 = 5.40 m = 17.717 ft

gear efficiency = (.94)^6 = 69 %

HP required for 1# force on Rack circle = 17.71 / (33,000 × .69) × 60/85 = .000549 HP

wind load. 巾 19.6 m = 64.3 ft 長 33.3 m = 109 ft area 64.3 × 109 = 7010 sq.ft
moment at trunnion = 7010 × 10# × 58.4 = 4,100,000 '#
wind load at Rack = 4,100,000 / 14.107 = 290,000# for 10#/□' wind
320,000 " 11 "
350,000 " 12 "

Total load on Rack :–
load on trunnion = 1050 tons = 2,300,000#
due to frictional resistance 2,300,000 × .15 × 8/169.3 = 16,300#
" " eccentric load " × 2/169.3 = 27,200
43,500#
" " wind load for 10#/□' = 290,000
333,500# for 2 girders

Required H.P = 333,500 × .000549 = 183 HP for 10#/□' wind
363,500 × " = 200 HP " 11 "
393,500 × " = 216 HP " 12 "
449,500 × " = 247 HP " 14 "
478,500 × " = 263 HP " 15 "

(240 HP ÷ .000549 = 437,000#)

Use motor 2-120 H.P = 240 H.P ~~558~~ 576 R.P.M. (assumed) at full load
220 V. 60 cycle 3 phase A.C induction motor

main pinion :–
circular pitch = 5¼" 20° involute teeth no. of teeth = 15
dia of pitch circle = 5.25 × 15 / π = 25.067" face of tooth = 18"
(out dia ≒ 20 3/8") y = .092 for 20° involute tooth

load on tooth = 437,000 / 2 = 218,500# for 1 pinion
intensity of stress on tooth S = 218,500 / (5.25 × 18 × .092) = 25,000 #/□" OK

No. of revolution of main pinion for 72° of Rack circle = 17.72 / (25.067 × π) = 2.250
78.750487
No of revolution of 1 min. = 2.25 × 60/85 = 1.588

Total gear ratio = ~~558~~ 576 / 1.588 = ~~352~~ 362.7204

use (49/15)^4 × 46/15 = 5764801/50625 × 46/15 = 113.87261 × ~~46~~ 48/15 = ~~349.21~~ 364.39 R.P.M

49 × 50 / 16 = 153.125
46 × 49 / 15 = 2254/15 = 150.267
47 × 48
48 × 52 = 2285
46 × 49 = 2254
48 × 50 46

増田淳氏関係資料
（独立行政法人 土木研究所蔵）

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CALCULATIONS FOR

1^{st} gear (15° involute teeth)

motor pinion:—

No. of teeth $N = 15$

diametral pitch $p_d = 1\frac{1}{2}$ (max dia of shaft 5.1" φ)

pitch dia. $d = 10"$ (out dia = $11\frac{3}{8}$")

circular pitch $p = 2.0944"$

face of tooth $f = 6"$

load on tooth $W = \frac{240 \times 33000 \times 12}{\pi \times 10 \times 558} = 5420^{\#}$ (558 corrected to 576; 5420 corrected to 5,250)

$y = .075$

speed of tooth $s = 10 \times \pi \times 558 \div 12 = 1460$ ft per min. (corrected: 576, 1510)

$$S = \frac{5420}{2.0944 \times 6 \times .075} = 5{,}770^{\#}/\square" < 7{,}000 \quad ok$$

(corrected: 5,250; 5,150)

spur wheel:—

$N = 46$ (corrected to 48)

$f = 5\frac{1}{2}"$

$d = 30.667"$ (corrected to 32") (O.D. $33\frac{3}{8}$")

2^{nd} gear (15° involute teeth)

pinion:—

$N = 15$

$p_d = 1\frac{1}{4}$

$d = 12"$ (O.D. $13\frac{5}{8}$") (max shaft 5.72" φ)

$p = 2.5133"$

$f = 6\frac{1}{2}"$

$W = 5420 \times \frac{30.667}{12} \times .94 = 13020$ (corrected: 5,250; 32"; 13,150#)

$s = 12 \times \pi \times \frac{558 \times 15}{46 \times 12} = 572$ ft per min. (corrected: 576; 48; 565)

$$S = \frac{13{,}020}{2.5133 \times 6.5 \times .075} = 10{,}640^{\#}/\square" < 13{,}000 \quad Ok$$

(corrected: 150; 10,720)

spur wheel:—

$N = 49$

$f = 6"$

$d = 39.2"$ ($40\frac{3}{4}$")

3^{rd} gear (15° involute teeth)

pinion:— (2^{nd} gear ノ spur wheel ヲ[illegible]中ハニ置キ 之レヨリ shaft ヲ左右ニ[illegible] 3^{rd} gear ヲ両端ニ設置ス。)

$N = 15$

$p_d = 1\frac{1}{4}$

$d = 12"$ (O.D. $13\frac{5}{8}$") (max. shaft 5.71" φ)

$p = 2.5133"$

$f = 6"$

$y = .075$

$W = \frac{13020 \times 39.2}{2 \times 12} \times .94 = 20{,}000^{\#}$ (13020 corrected to 13150)

$s = 572 \times \frac{12}{39.2} = 175$ ft per min.

$$S = \frac{20{,}000}{2.5133 \times 6 \times .075} = 17{,}700^{\#}/\square" < 20{,}000 \quad Ok$$

spur wheel:—

$N = 49$

$f = 5\frac{1}{2}"$

$d = 39.2"$ (O.D. $40\frac{3}{4}$")

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CALCULATIONS FOR

4th gear (15° involute teeth)

pinion :—

$N = 15$

$P_d = 1$

$d = 15''$ (O.D 17") (max. shaft 7"64φ)

$p = 3.1416$

$f = 8\frac{1}{2}''$

$W = 20{,}000 \times \frac{39.2}{15} \times .94 = 49{,}100\#$

$S = \frac{49{,}100}{\pi \times 8.5 \times 1.075} = 24{,}500\ \#/in^2 < 25{,}000$ OK

Spur wheel :—

$N = 49$

$f = 8''$

$d = 49''$ (O.D 51") (12 φ)

5-th gear (20° involute teeth)

pinion :—

$N = 15$

$P = 4''$

$d = \frac{4 \times 15}{\pi} = 19.099''$ (O.D = 21½")

$f = 12\frac{1}{2}''$

$W = 49{,}100 \times \frac{49}{19.099} \times .94 = 118{,}300\#$

$y = .092$

$S = \frac{118{,}300}{4 \times 12.5 \times .092} = 25{,}700$ OK

Spure wheel :—

$N = 49$

$f = 12''$

$d = 62.389''$ (O.D 64") (15φ)

main pinion & Rack (6th gear) 20° involute teeth

Rack

$d = 25.067''$ (16")

$W = 118{,}300 \times \frac{62.389}{25.067} \times .94^2 = 260{,}000\#$

1660.0735-36

~~2660.0735-36~~

$\sqrt{1660.0735-36}$ = 35.497514

32.6667

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$\frac{31}{15} \times \frac{45}{15}$

CALCULATIONS FOR

MADE BY ________ DATE 6-12-10 FILE NO 3'

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Gears for 1 motor operate
1st motor shaft pinion :—

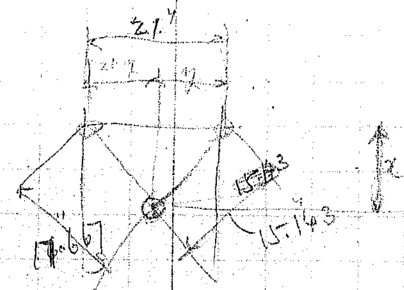
(注1 歯車ハ強風時ニ1台モーター除用フルモニツキ 所要モーター時間ハ普通ノ2倍 即チ3分20秒ニテ開又ハ閉ヲナス。但シ無風ノ際ハ1台モーター ト雖モ之歯車ヲ使用スル必要ナシ。)

$N = 15$
$P_d = 1\frac{3}{4}$
$d = 8.571$
$P = 1.7952$
$f = 5"$

8.571
21.714
$2)\overline{30.285}$ (15.143

Spur wheel :— (中間軸)
$N = 38$ (~~38~~)
$d = ~~17.714~~\ 21.714"$
$f = 4\frac{1}{2}$

10.
25.333
$2)\overline{35.333}$ (17.667



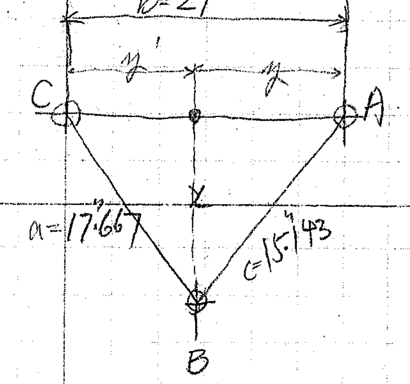
2nd gear
pinion :— (中間軸)
$N = 15$
$P_d = 1\frac{1}{2}"$
$d = 10"$
$p = 2.0944$
$f = 6"$

$\sqrt{15.143^2 - y^2} = \sqrt{17.667^2 - (21-y)^2}$

$15.143^2 - y^2 = 17.667^2 -$

spur wheel :— (2nd shaft)
$N = 38$ (~~45~~)
$d = ~~30~~\ 25.333$
$f = 5\frac{1}{2}"$

gear ratio (total) $\frac{38 \times 38}{15 \times 15} = 6.42$



$\sin \frac{1}{2}A = \sqrt{\frac{(s-b)(s-c)}{bc}}$

$441 - 21y$
$-21y + y^2$

where $s = \frac{17.667+15.143+21}{2} = \frac{53.81}{2} = 26.905"$

$\sin\frac{1}{2}A = \sqrt{\frac{(26.905-21)(26.905-15.143)}{21 \times 15.143}} = \sqrt{\frac{5.905 \times 11.762}{318.003}}$

$= \sqrt{.21840866} = .467342$

∴ $\sin\frac{1}{2}A = 27°50'$ $\sin A = 55°40'$

$x = 15.143 \times \sin 55°40' = 15.143 \times .82577$
$= 12.50463"$

$y = \sqrt{15.143^2 - 12.50463^2} = \sqrt{229.310449 - 156.3657714}$
$= \sqrt{72.9446776} = 8.53"$

$y' = \sqrt{17.667^2 - 12.50463^2} = \sqrt{312.112307 - 156.3657714}$
$= \sqrt{155.7465356} = 12.470"$

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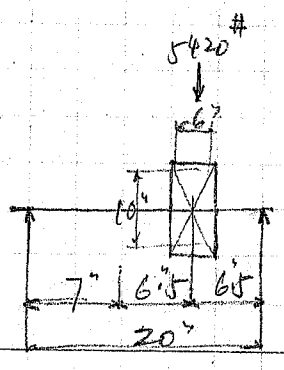
CALCULATIONS FOR

SHAFTS

Motor shaft :— (軸受間)



$M_b = \frac{5420 \times 65}{20} \times 13.5 = 28,200$ "#

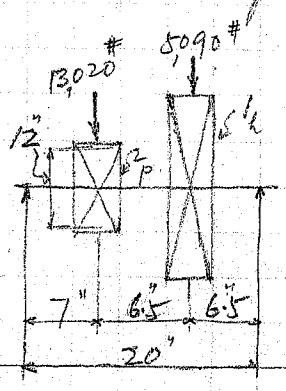
$M_t = 5420 \times 5 = 27,100$ "#

$M_e = 28,200 + \sqrt{28,200^2 + 27,100^2} = 67,300$ "#

$\therefore d = 1.72 \sqrt[3]{\frac{67,300}{9,000}} = 1.72 \times 1.956 = 3.36$ "

say $3\frac{3}{4}$" 4"

1st shaft :— (軸受鋼)



$M_b = \frac{13,020 \times 13 + 5090 \times 65}{20} \times 7 = 70,800$ "#

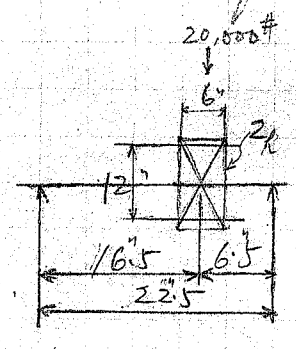
$M_t = 13,020 \times 6 = 78,200$ "#

$M_e = 70,800 + \sqrt{70,800^2 + 78,200^2} = 176,300$ "#

$\therefore d = 1.72 \sqrt[3]{\frac{176,300}{9,000}} = 1.72 \times 2.696 = 4.64$ "

say $4\frac{3}{4}$"φ

2nd shaft :— (軸受鋼)



$M_b = \frac{20,000 \times 6.5}{22.5} \times 16.5 = 192,500$ "#

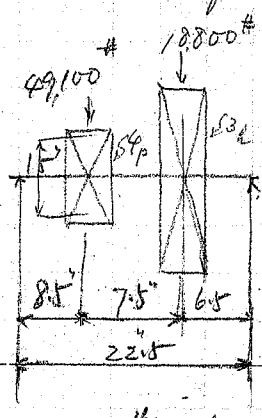
$M_t = 20,000 \times 6 = 120,000$ "#

$M_e = 192,500 + \sqrt{192,500^2 + 120,000^2} = 243,500$ "#

$\therefore d = 1.72 \sqrt[3]{\frac{243,500}{9,000}} = 1.72 \times 3.004 = 5.17$ "

say $5\frac{3}{4}$"φ

3rd shaft :— (半硬鋼)



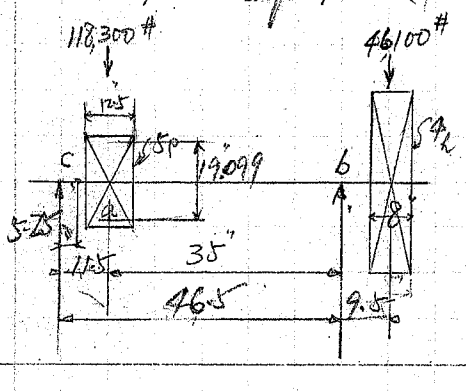
$M_b = \frac{49,100 \times 14 + 18,800 \times 6.5}{22.5} \times 8.5 = 288,000$ "#

$M_t = 49,100 \times 7.5 = 368,000$ "#

$M_e = 288,000 + \sqrt{288,000^2 + 368,000^2} = 755,000$ "#

$\therefore d = 1.72 \sqrt[3]{\frac{755,000}{12,500}} = 1.72 \times 3.929 = 6.75$ "# say 7"φ (at Bearing 、$6\frac{3}{4}$"φ)

4th shaft :— (半硬鋼)



at a

$M_b = \frac{118,300 \times 35}{46.5} \times 1.15 = 1,025,000$ "#

$M_t = 118,300 \times 9.55 = 1,130,000$ "#

$M_e = 1,025,000 + \sqrt{1,025,000^2 + 1,130,000^2} = 2,498,000$ "#

$\therefore d = 1.72 \sqrt[3]{\frac{2,498,000}{13,000}} = 1.72 \times 5.759 = 9.9$ " say 10" (use 2 Kayo)

~~mat dia of shaft = $\frac{15 - 5.46}{.786} \times \frac{5}{5} = 9.7$~~ OK

at b

$M_b = 46100 \times 9.5 = 438,000$ "#

$M_t = 1,130,000$

$M_e = 438,000 + \sqrt{438,000^2 + 1,130,000^2} = 1,649,000$ "#

$\therefore d = 1.72 \sqrt[3]{\frac{1,649,000}{13,000}} = 1.72 \times 5.020 = 8.63$ " say $8\frac{3}{4}$"

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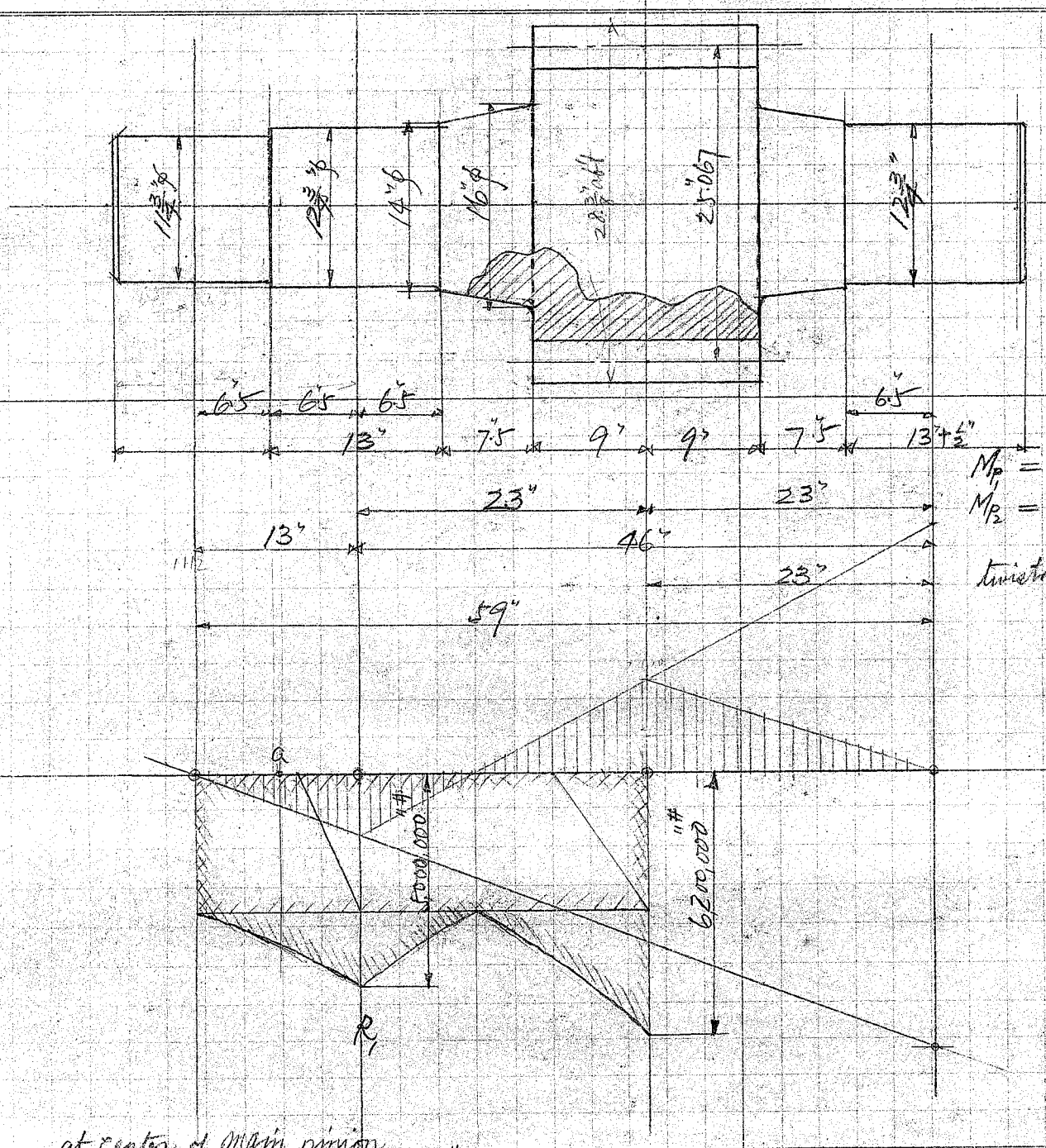
CALCULATIONS FOR



M_{P_1} = 111200 × 59 = 6540,000 in#

M_{P_2} = 260,000 × 23 = 5,980,000 in#

twisting mt = 260,000 × 12.53 = 3,260,000 in#

at center of main pinion

M_e = 6200,000 in#

dia. of shaft $d = 1.72\sqrt[3]{\frac{6,200,000}{13,000}} = 1.72 \times 7.813 = 13.42"$

at point of R_1

M_e = 5,000,000 in#

$d = 1.72\sqrt[3]{\frac{5,000,000}{13,000}} = 1.72 \times 7.272 = 12.5"$ say $12\frac{3}{4}$"

at a M_e = 4,000,000 $d = 1.72\sqrt[3]{\frac{4000,000}{13,000}} = 1.72 \times 6.753 = 11.62"$ say $11\frac{3}{4}$"

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CALCULATIONS FOR

Estimate of Cost of Bascule Bridge for Toshin-kyo, Fusan, Korea.

Estimate of Structural Steel.

Moving parts

Stringers	34 metres	@	1006 kg	=	34200
Floor Beams	8	@	4300	=	34400
Latral Bracing with gussets	31 metres	@	400	=	12400
Latral under stringers	31 "	@	350	=	10900
Latral Cross struts	3	@	700	=	2100
Longitudinal struts	31 metres	@	170	=	5300
Sidewalk Bracket	7	@	700	=	4900
Cross Frame at floor brake	13 "	@	100	=	1300
Floor brake one side	19 "	@	150	=	2900
Main girders	2	@	82,000	=	164000
Cwt girders complete					65000
Rear of Trunnion					
Cross strut	2	@	2800	=	5600
" "	3	@	3500	=	10500
Longl strut	5	@	750	=	3800
" "	2	@	400	=	800
Upper Framing					4000
Lower Framing					5000
Links for Cwt & shoes					2900
					370.000 kg.

Fixed Parts

Floor beam	1	@		=	3000
"	1	@		=	4000
Stringers	8.5	@	1200	=	10200
Floor brake	30.0	@	150	=	4500
Struts etc,					3300
					25,000 kg
metal in cols	2	@	15000	=	30,000
Brackets &c for cols	2	@	5000	=	10.000
Live load shoes & centering castings					5000
Trolley Poles	4	@	4500	=	18.000
" Arms	2	@	1000	=	2000
Stairs & Ladders					5000
Exp. Joints at front & rear	2	@	2000	=	4000
Misc. say					1000
					75.000 kg
					470,000 kg
Variation say					30.000
					500.000 kg.

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CALCULATIONS FOR

Estimate of Cast for Cascade span for Joshin-kyo, Fusan, Korea.
Machinery Parts.

Operating gears (machine cut)	hard steel		4760 kg
	Cast steel		13400
Operating shafts (finished)	medium steel		1270
	hard steel		1950
Bearing Blocks (excluding Bronze Bushings)	cast iron		8620
Couplings with bolts 2 sets	Cast iron		360
Gear Covers angles + plate			200
Clutches + accessories	cast steel		80
	Phosphor Bronze		20
	Medium Steel		70
	Cast iron		110
Hand brakes	Cast iron		270
	medium steel		230
Structural Steel Bases + anchor bolts			2500
Air Buffers 4 sets	Cast Steel		950
	Cast iron		500
	Medium Steel.		500
Locking Apparatus and Barrier Gate (gears + machinery complete)			3630
Indicator	Steel.		90
		39510	
Add for miscellaneous		3490	
Total for machinery parts.			43.000 kgs
Trunnion shafts, bearings and bosses. complete with finishing		say	12.000
			55.000 kgs.

Grand Summary for machine Parts. 55.0 tons

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CALCULATIONS FOR

Estimate of Cost for Bascule Bridge.

Estimate of Cost.

Moving or Leaf

Highway and Railway Floor

Floor planking and pavement	34 × 12.6 = 430 m²	@	20.00	= 8600
Sidewalk flooring	34 × .53 = 180 "	@	11.00	= 1980
Track rails & accessories	34 × .22 = 7.5 tons	@	140.00	= 1050
Sleepers	60 pcs	@	18.00	= 1080
Handrail	34 × .16 = 5.5 tons	@	220.00	= 1210
Miscellaneous				180
				14100

Fixed Floor on Bascule Abutment

Asphalt Block Pavement	10 × 12.6 = 126 m²	@	5.00	= 630
Sidewalk floor pavement	10 × 5.4 = 54 "	@	4.00	= 220
Track rails	2.2 tons	@	140.0	= 310
Sleepers	40 pcs	@	6.0	= 240
Handrail	10 × .16 = 1.6 tons	@	220.0	= 350
Concrete Slab	10 × 20 = 200 m²	@	6.00	= 1200
Misc.				50
				3000

Structural Steel complete 500 tons @ 170.00 = 85000

Concrete Counter weights

Cement mortar	160 m³	@	30	= 4800
Steel Scraps	424 tons	@	40	= 17000
Main Reinforcing Bars	5 tons	@	100	= 5000
Staging & miscellaneous				200
				27000

Machinery Parts complete 55.0 tons @ 600.00 = 33000

Motors and Electric Equipments

2 - 100 HP motors and accessories	2 @ 2000	=	4000
1 - 2 HP motor etc			110
1 - 1 HP " etc			90
Transformers, Switch boards & wirings complete			4200
			8400
50 HP Gasoline Engine with accessories			3000
Miscellaneous accomodations for trolley			8000
Operating House and Stand			1500
Miscellaneous			1000
			21900

Summary

Moving Floor Construction	14100	
Fixed Floor "	3000	
Structural Steel	85000	
Counter weights	27000	
Machinery parts	33000	
Motors & misc.	21900	
		184000 ¥
Design Fee		16000
Total cost for Superstructure		200000 ¥