# *21. Kasokudo-disinkei no Seisaku oyobi Kenkyû.*

TAMARU-Takurô.*

## Mokuzi.

Yôryô.
Riron oyobi Sekkei.
Zentai no Sekkei oyobi Ryô no kikagakutekina Kwankei.
Undô no Hôteisiki.
Kasokudo no Domori, Hyô oyobi Kyokusen wo soeru.
Omori no Sekkei.
Omori wo sasaeru Bane no Sekkei.
Teko $S_1$ $S_2$ oyobi sonohokano Bubun no Sekkei.
Ondo no Eikyô.
Sisin no Hazi no Masatu.
Hokano Seibun wo sirusu Bubun no Eikyô.
Dimen-keisya no Eikyô.
Ziko-sindô no Eikyô.
Hito no kanzinai Disin wo kirokusuru Kikai.
Genzai Sekkei no Kikai, Hiyô, Ryakudu wo soeru.

## Yôryô.

**1.** Koremadeno Disinkei niwa Dimen no Undô no Hen'i wo kirokusuru mono to Sokudo wo kirokusuru mono to aru. Korerano Kikai wa rikigakutekini syuyôna Bubun ni oitewa dôyôna mono de, yôsurunii Disin no saini Dimen no Undô ni narubeku tomonawarenai yôna Omor, wo sôtisi, sore ni taisite Dimen no Hen'i matawa Sokudo wo kirokusuru mono de aru.

Kokoni tukurô to suru Kasokudo-disinkei wa, sorera to mattaku kotonaru Sayô ni motoduite, tyokusetuni Dimen no Undô no Kasokudo wo kirokusuru mono de aru.

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* Kono Ronbun wa Tamaru Hakusi ga katute watakusi ni kasi-ataerareta mono de aru ga, Konniti dewa Hakusi no Sigoto tosite nokosareta mono no hitotu to natta sidai de aru. Hakusi wa Taisyô 6 nen ni Nippon Sûgaku-Buturi Gakkwai ni oite, mata Syôwa 2 nen ni Teikoku Gakusiin ni oite dôyôno Ronbun wo yomareta no de aru. Zensya wa insatusarenaide owari, Kôsya wa Teikoku Gakusiin Kizi [3 (1927), 35] to site kantanna Hôkoku ni todomatte iru. Sitagatte kono Ronbun wa Hakusi no kono Hômen no Kenkyû tosite mottomo kuwasiku kakarete iru mono tosite Neuti ga aru to omou. Hakusi no Kenkyû wo eikyûni tutaetai to omou Hitobito no Kibô kara Ooyake to sareru sidai de aru. Genbun wa Kwanzimaziri de kakareta mono de aru ga nisanno Katagata no Gotyûi ni yori Tauti Hakusi ni onegai site Rôma zi-gaki to nasita mono de aru. (Ishimoto-M.)

**2.** Ittai, Disin ni okeru Dimen no Undô ni tuitewa, Hen'i yorimo musiro Kasokudo no hô ga syuzyuno Ten de kaette yôyôna Kwankei ga aru yôni omowareru (tatoeba Tatemono no Tagui ga Disin no tameni ukeru Muri wa Kasokudo no Ookisa ni sitagau mono de aru) noni, Hen'i matawa Sokudo no Kiroku kara Kasokudo wo keisansuru koto wa seimituni okonawarenikui kara, tyokusetuni Kasokudo wo kirokusuru Disinkei ga tukurare uru naraba kiwamete yûyôna mono de arô to omowareru.

Sin'anno Disinkei wa kono Imi de omosiroi dake de naku sekkei-oyobi zituyôzyônimo, koremadeno Disinkei ni kurabete, (a) Higasi-nisi, Minami-kita, Ue-sita sanbôno Undô wo tada hitotuno Omori wo tukatte, sikamo mattaku dôyôna Sôti wo tukatte kakase uru koto, (b) koremadeno Disinkei ga huantei ni tikai Sôti de aru ni hansite kiwamete anteina Sôti de aru koto, (c) koremadeno Disinkei ni kurabete Ziko-sindô no Samatage wa sukunaku, Ondo-henkwa kara syôzuru Konnan wo sukuu nimo tayasui yôni yosôsareru koto nado, Omomuki no tigau Ten ga sukunaku nai node, katagata Seisaku wo kokoromi kenkyûsuru Neuti ga aru mono to sinzuru.

**3.** Nao, sin'anno Disinkei niwa, betuno Hômen ni oite atarasii Kuhû wo site aru. Sore wa, koremadeno Kikai dewa Oodisin no tokini Sisin ga amari ôkina Sindô wo nasi ôkuwa Kirokugami no sotoni hadure-satte zyûbunno Yô wo sinai koto wo manukareru tameni, tokubetuna Sôti wo môkete Sisin no Undô-kuiki wo itteino Kagiri inaini tomeru yôni sita koto de aru.

## Riron oyobi Sekkei.

**4.** Kokoni kokoromiyô to omou Kasokudo-disinkei no Mokuteki taru Kasokudo wo kirokusaseru koto no konponno Kangae wa, sôtôni ôkina Situryô wo motu Omori ni Dimen to onazi Undô wo saseru yôni sôtisi, Omori to sore wo sasaeru Bubun to no aidani okonawareru Tikara wo kirokusaseru ni aru. Kono Tikara wa, Omori wo site Dimen to onazi Undô wo saseru ni hituyôna Tikara de aru kara, tadatini Dimen-undô no Kasokudo ni hireisuru no de aru.

Tanni kono Tikara wo kirokusuru dakeno Mokuteki naraba, Omori wo sasaeru no ni Ue-sita, Higasi-nisi, Minami-kita, subete no Hôkô ni oite tuyoi Bane wo tukai, kono Bane no kiwamete tiisai Undô wo hi-zyôni ôkiku site kirokusasereba yoi. Bane ga tuyoi kara, Omori no Undô wa Dimen no Undô to onazi to mirareru (Sa wa sûhyakubunno iti ni suginai yôni tukuru koto ga dekiru), mata Bane no Henkei wa, kore to

Omori to no aidani hataraku Tikara no Henkwa ni hireisuru kara, konoyôni site eru Kiroku wa Kasokudo wo simesu koto ni naru.

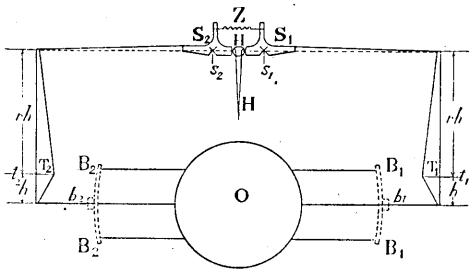
**5.** Kokoni sekkeisite aru Kikai dewa, 3 ni nobeta Mokuteki ga aru node, Omori wo sasaeru no ni tanni tuyoi Bane wo tukau koto ni sezu, Dai 1 Du oyobi Dai 2 Du ni simesu yôna Sikake ni yotte, Omori ni sayôsuru Tikara (sunawati Omori ni Dimen to onazi Undô wo saseru ni hituyôna Tikara) ga ôkiku naru ni sitagatte, Sisin no Kanzi ga sidaini nibuku natte, kono Tikara ga dokomademo ôkiku nareba, Sisin no Muki ga itteino Iti ni tikaduku yôni site aru.

**6.** Ima kono Kikai no uti, suiheina hitotuno Hôkô no Disindô no Kasokudo wo kirokusuru Bubun dake ni tuite Sikake no Ryakudu wo kakagete rironzyôno Keisan wo suru.

## Zentai no Sekkei oyobi Ryô no kikagakutekina Kwankei.

**7.** Miginono Du(Dai 1 Du) wa Suihei-hôkô no Kasokudo sirusu Bubun no Heimendu wo wo simesu.

O wa Omori, kore no Omosa wo sasaeru Sôt iwa Du ni simesite nai ga, Sayû-hôkô no Undô wo samatagenai yôni site aru.



Dai 1 Du.

$B_1 B_1$, $B_2 B_2$ wa Bane, $b_1 b_2$ de koteisite aru.

$T_1 T_2$, wa Teko, $t_1 t_2$ de sasaete aru. Kore to $o$ to no aida wa tawamiyasui Obi de tunaide aru.

$S_1 S_2$ wa sanbôhidino Teko, $s_1 s_2$ ni Siten ga aru. Ippô wa $T_1 T_2$ ni tunagari, ippô wa Zenmaibane $Z$ de tagaini renrakusi, nokoru ippô wa Sisin $H H$ no Entyû-bubun wo hasande, onore no Undô de kono Entyû wo mawasi, sitagatte Hari no Hazi wo ugokasu yôni sôtisite aru.

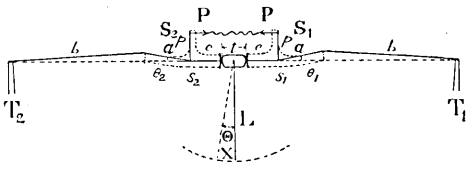
Zentai no Sôti ga Migi-hidari taisyôni tukutte atte, Turiai no Iti ni oite $T_1 T_2$ no $S_1 S_2$ ni renrakusuru Hazi wo musubu Tyokusen no ueni Siten $s_1 s_2$ no aru yôni, sikamo $S_1 S_2$ no $T_1 T_2$ ni renrakusuru Ten wa kono Tyokusen wo sukosi hadurete iru yôni site aru.

Dimen no Hen'i wo migino hô ni $\xi$ to si, Dimen ni taisite Turiai no Iti kara Omori noututta Hen'i wo onaziku migino hô ni $x$ to suru.

Teko $T_1 T_2$ no Hidi no Nagasa wo Dai 1 Du ni simesita yôni $h$, $rh$ to suru.

Teko $S_1 S_2$ ni kwansuru Ryô wo sitano Du (Dai 2 Du) ni sirusu yôni toru.

$x=0$ ni taisite $\theta_1=\theta_2=\theta_0$ to si, $x$, $\theta_1$, $\theta_2$, Hari no Kwaiten no Kaku $\theta$, Hari no Hazi no Hure $X$ nado no Kwankei wo siraberu.



Dai 2 Du.

Omori no Hen'i $x$ ni taisite, $T_1 T_2$ no $S_1 S_2$ ni turanaru Hazi no Hen'i wa $rx$ de, kore wa kiwamete tiisai Ryô de aru. Mata $\theta_1, \theta_2$ mo tuneni hanahada tiisai yue,

$$\left(a\cos\theta_0+b\cos\frac{a\theta_0}{b}\right)-\left(a\cos\theta_1+b\cos\frac{a\theta_1}{b}\right)=rx,$$

$$\left(a\cos\theta_2+b\cos\frac{a\theta_2}{b}\right)-\left(a\cos\theta_0+b\cos\frac{a\theta_0}{b}\right)=rx$$

wa tugino yôni naru

$$a\frac{\theta_1^2-\theta_0^2}{2}+\frac{b}{2}\frac{a^2}{b^2}(\theta_1^2-\theta_0^2)=rx,$$

sunawati $\theta_1^2-\theta_0^2=\dfrac{2r}{a'}x$ : Tadasi $a'=a\left(1+\dfrac{a}{b}\right)$.

Dôyôni $\theta_2^2-\theta_0^2=-\dfrac{2r}{a'}x$.

Sitagatte $\theta_1^2+\theta_2^2=2\theta_0^2$, $\theta_1^2-\theta_2^2=\dfrac{4r}{a'}x$.

Mata $X=L\Theta=L\dfrac{c(\overline{\theta_1-\theta_0}+\overline{\theta_0-\theta_2})}{t}=\dfrac{Lc}{t}(\theta_1-\theta_2)$,

$\theta_1-\theta_2=\theta$ to kakeba, $\theta_1+\theta_2=\sqrt{4\theta_0^2-\theta^2}$.

Sitagatte $\theta_1=\dfrac{1}{2}(\sqrt{4\theta_0^2-\theta^2}+\theta)$, $\theta_2=\dfrac{1}{2}(\sqrt{4\theta_0^2-\theta^2}-\theta)$, $x=\dfrac{a'}{4r}\theta\sqrt{4\theta_0^2-\theta^2}$;

$$\theta=\theta\frac{t}{c}=X\frac{t}{Lc}.$$

Benri no tameni $\theta=2\theta_0\sin\varphi$
to site Hozyo-no-Kaku $\varphi$ wo tukaeba,

$$\theta=2\theta_0\frac{c}{t}\sin\varphi, \qquad X=2L\theta_0\frac{c}{t}\sin\varphi,$$

$$\theta_1=\sqrt{2}\theta_0\sin\left(\frac{\pi}{4}+\varphi\right), \qquad \theta_2=\sqrt{2}\theta_0\sin\left(\frac{\pi}{4}-\varphi\right),$$

$$x=\frac{a'}{r}\theta_0^2\sin\varphi\cos\varphi=\frac{a'}{2r}\theta_0^2\sin 2\varphi.$$

Omori ni hoka kara Tikara ga sayôsuru ni yotte syôzuru kyokutanno Atai wa $\theta_2=0$, matawa $\theta_1=0$ no Baai de, tugino tôri,—

$$\theta=\pm\sqrt{2}\theta_0,\ \varphi=\pm\frac{\pi}{4},\ x=\pm\frac{a'\theta_0^2}{2r},\ \Theta=\sqrt{2}\theta_0\frac{c}{t},\ X=\sqrt{2}\theta_0\frac{cL}{t}.$$

Genzaino Sekkei dewa kono kyokutanno $x$ wa 0·00373 cm. ni naru. Kore ni yottemo Omori ga Dimen to issyoni ugokasarete iru to mite yoi koto ga sireru.

[Tyûi : $\theta_1\theta_2$ ga $\theta_0$ wo hedataru koto ga ôku naruto, dôzini okoru ryôhô no Henkwaryô ga hitosiku naku nari, sono kekkwa Sisin no Ziku no Iti ga sukosi sotono hô ni uturu wake de aru ga, kore no tameni Sisin to $S_1S_2$ to no aidano Renraku (usui Hagane-ita wo tukau) ni Sasitukae wo syôzuru Teido niwa naranai to omowareru.]

## Undô no Hôteisiki.

**8.** Omori no Situryô wo $m$, Teko $T_1(T_2)$, $S_1(S_2)$, Sisin $H$ no Kwansei-moment wo sorezore $M, M', M''$ to sureba, Undô-seiryoku $T$ wa

$$T=\frac{m}{2}(\dot\xi+\dot x)^2+2\cdot\frac{M}{2}\left(\frac{\dot x}{h}\right)^2+\frac{M'}{2}(\dot\theta_1^2+\dot\theta_2^2)+\frac{M''}{2}\dot\theta^2$$
$$=\frac{m}{2}(\dot\xi+\dot x)^2+\frac{M}{h^2}\dot x^2+\left(M'+2M''\frac{c^2}{t^2}\cos^2\varphi\right)\theta_0^2\left(\frac{d\varphi}{dx}\right)^2\dot x^2.$$

Tugini Iti-seiryoku $V$ wo kangaeru ni,

Bane $B_1B_1$, $B_2B_2$ no $x$ ni taisuru Tikara no Keisû wo onoonono Hazi ni tuki $K$,

Zenmaibane $Z$ no Tyôryoku wo $P$,

Teko $S_1S_2$ wo sasaete iru Bane no $\theta$ ni taisuru Nôritu no Keisû wo $k$

to sureba,

$$V=4\cdot\frac{1}{2}Kx^2+Pp(\overline{\theta_0-\theta_2}-\overline{\theta_1-\theta_0})+\frac{1}{2}k(\overline{\theta_1-\theta_0}^2+\overline{\theta_2-\theta_0}^2)$$
$$=2Kx^2+2(Pp\theta_0+k\theta_0^2)(1-\cos\varphi),$$

Sitagatte Undô no Hôteisiki wa tugino yôni naru.

$$\left\{m+\frac{2M}{h^2}+2\left(M'+2M''\frac{c^2}{t^2}\cos^2\varphi\right)\theta_0^2\left(\frac{d\varphi}{dx}\right)^2\right\}\ddot x+\frac{d}{dx}\left[\left(M'\right.\right.$$
$$\left.\left.+2M''\frac{c^2}{t^2}\cos^2\varphi\right)\left(\frac{d\varphi}{dx}\right)^2\right]\theta_0^2\dot x^2+4Kx+2(Pp\theta_0+k\theta_0^2)\sin\varphi\frac{d\varphi}{dx}=-m\ddot\xi.$$

Kasokudo-disinkei dewa, Ziko-sindô no Syûki wo tiisaku site, $\ddot{\xi}$ no Atai ga ôku kawaranai utini Ziko-sindô ga sûkwai okonawarete sono heikinno Iti sunawati genzaino $\ddot{\xi}$ ni taisite turiau Iti ga simesareru yôni suru no de aru.

## Kasokudo no Domori.

**9.** Turiau Iti wa

$$4Kx+2(Pp\theta_0+k\theta_0^2)\sin\varphi\frac{d\varphi}{dx}=-m\ddot{\xi}$$

de ataerareru. Soreyueni

$$-\ddot{\xi}=\frac{4K}{m}\frac{a'}{2r}\theta_0^2\sin 2\varphi+\frac{2r(Pp+k\theta_0)}{ma'\theta_0}\frac{\sin\varphi}{\cos 2\varphi},$$

Ima $$\alpha=\frac{4Ka'}{mr}\theta_0^2,\ \beta=\frac{2r(Pp+k\theta_0)}{ma'\theta_0},\ \beta=\mu\alpha$$

to okeba

$$-\ddot{\xi}=\alpha\frac{\sin 2\varphi}{2}+\beta\frac{\sin\varphi}{\cos 2\varphi}=\alpha\left(\frac{\sin 2\varphi}{2}+\mu\frac{\sin\varphi}{\cos 2\varphi}\right).$$

$\ddot{\xi}=0$ wa $\varphi=0$ ni atari, $\ddot{\xi}=\infty$ wa $\varphi=\frac{\pi}{4}$ ni ataru. Sisin no Hazi no Hure no tiisai Sa de arawasareru Kasokudo no Sa no Wariai wa

$$\frac{\partial(-\ddot{\xi})}{\partial X}=\alpha\left\{\cos 2\varphi+\mu\left(\frac{\cos\varphi}{\cos 2\varphi}+\frac{2\sin\varphi\sin 2\varphi}{\cos^2 2\varphi}\right)\right\}\frac{t}{2Lc\theta_0\cos\varphi}.$$

Kono Wariai ga $\varphi=0$ kara $\varphi=\frac{\pi}{4}$ made sidaini masu yôni toru ga yoi. Sore niwa tugino Siki wo itumo (+) ni suru koto ga hituyô de aru.

$$\frac{\partial^2(-\ddot{\xi})}{\partial X^2}=\frac{\alpha t^2}{4c^2L^2\theta_0^2}\frac{\sin\varphi}{\cos\varphi}(2+\sec^2\varphi)$$
$$\times\left[-1+4\mu\left(\frac{1+\cos^2\varphi}{1+2\cos^2\varphi}\cdot\frac{\cos\varphi}{\cos^2 2\varphi}+\frac{1+4\sin^2\varphi\cos^2\varphi}{1+2\cos^2\varphi}\cdot\frac{\cos\varphi}{\cos^3 2\varphi}\right)\right].$$

Kono Siki wa $\varphi=0$ no tokini (+) naraba tuneni (+) de aru. Sore niwa.

$$\mu>\frac{1}{4}.$$

Genzaino Sekkei dewa, sitani simesu hokano Dyôken kara $\mu=0{\cdot}35$ ni totte aru. Mata $\alpha$ no Atai wa $89{\cdot}0\frac{\text{cm}}{\text{sec}^2}$ ni natte iru. Kore de kan-

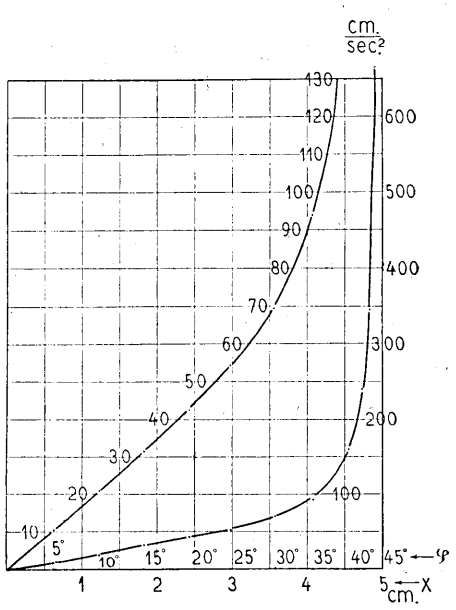
dyôsuruto, tugino Hyô (Dai 1 Hyô) oyobi Kyokusen (Dai 3 Du) ni simesu yôna Kasokudo no Domori wo eru.

Dai 1 Hyô.

| $\varphi$ | $X$(cm) | $-\ddot{\xi}\left(\frac{\text{cm}}{\text{sec}^2}\right)$ | $\varphi$ | $X$(cm) | $-\ddot{\xi}\left(\frac{\text{cm}}{\text{sec}^2}\right)$ |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 35 | 4·06 | 93·9 |
| 5 | 0·62 | 10·5 | 40 | 4·55 | 159·0 |
| 10 | 1·23 | 21·0 | 42 | 4·73 | 243·1 |
| 15 | 1·83 | 31·6 | 43 | 4·82 | 348·4 |
| 20 | 2·42 | 42·6 | 44 | 4·91 | 660·0 |
| 25 | 2·99 | 54·6 | 45 | 5·00 | $\infty$ |
| 30 | 3·54 | 69·7 | | | |

Tokuni Hure no tiisai Kuiki dewa, $X$ no 1 mm ga Kasokudo no 17 $\frac{\text{mm}}{\text{sec}^2}$ ni atatte iru.

Mata Disin no Undô ga Sinpuku $A$ cm, Syûki $T_D$ byô no Tansindô da to kateisureba, Saidai-kasokudo wa $4\pi^2\frac{A}{T_D^2}$ de, kore wa, tuyoku nai Disin dewa $X=\frac{1}{17}4\pi^2 \times\frac{1}{T_D^2}A$ cm ni arawareru. Soreyue kono Disinkei ga Hen'i wo arawasu Bairitu wa $\frac{4\pi^2}{17}\frac{1}{T_D^2}$ ni naru. $T_D=0{\cdot}5$ no Baai niwa oyoso 9·5-bai, $T_D=1$ no Baai niwa oyoso 2·3-bai ni naru. Mata konotoki Omori no Dimen ni taisite ugoku Kyori wa $X$ no $\frac{1}{947}$



Dai 3 Du.

de, $T_D=0{\cdot}5$ no tokini Dimen no Undô no $\frac{1}{100}$, $T_D=1$ no tokini oyoso $\frac{1}{250}$ de aru. Kore demo Omori ga Dimen to Undô wo tomonisite iru to mite ôkina Ayamari no nai koto ga sireru.

## Omori no Sekkei.

**10.** Omori no Situryô no Saisyôgen wa, hanahada tiisai Kasokuko wo kaku koto wo Mokuteki to suru no de nakereba, Ziko-sindô no Syûki to Kasokudo-domori no Wariai to kara kimaru. Ziko-sindô no Syûki wa $\varphi$ no tiisai tokini ôkiku, $\varphi$ ga yaya ôkiku nareba itizirusiku tiisaku naru kara, $\varphi$ no tiisai Baai ni tyûisureba tariru.

$\varphi$ no tiisai Baai no Syûki $T'$ wa

$$\left\{m+\frac{2M}{h^2}+2\left(M'+2M''\frac{c^2}{t^2}\right)\theta_0^2\frac{r^2}{a'^2\theta_0^4}\right\}\ddot{x}$$
$$+\left\{4K+2(Pp\theta_0+kq_0^2)\frac{r^2}{a'^2\theta_0^4}\right\}x=0$$

kara, $\mu=\frac{\beta}{\alpha}=\frac{(Pp+k\theta_0)r^2}{2a'^2\theta_0^3K}$ wo tukatte tugino Siki de ataerarereru,

$$T^2=\pi^2\frac{m+\frac{2M}{h^2}+2\left(M'+2M''\frac{c^2}{t^2}\right)\frac{r^2}{a'^2\theta_0^2}}{K(1+\mu)}.$$

Ima kono $T'$ oyobi tiisai $\varphi$ ni taisuru

$$\frac{-\ddot{\xi}}{X}=\frac{\alpha+\beta}{\frac{Lc}{t}2\theta_0}=\frac{4Ka'\theta_0t(1+\mu)}{2mrLc}=q$$

ga ataete aru to site, $m$ oyobi $K(1+\mu)$ wo sirô to suruto,

$$m=\frac{\frac{2M}{h^2}+2M'\frac{r^2}{a'^2\theta_0^2}+4M''\frac{c^2r^2}{t^2a'^2\theta_0^2}}{\frac{T^2}{2\pi^2}Lq\frac{cr}{ta'\theta_0}-1}.$$

$$K(1+\mu)=\frac{mrLcq}{2a'\theta_0t}$$

to naru. Ima tiisai $\varphi$ ni taisuru $\frac{X}{x}$ wo "Kwakudairitu" $N_0$ to sureba,

$$N_0=\frac{X}{x}=\frac{2Lrc}{a't\theta_0},\quad \text{sitagatte}\ \frac{rc}{ta'\theta_0}=\frac{N_0}{2L}$$

Kore wa ôkina Kazu de nakereba naranai. Mata Sisin niwa, Kyokusen wo kakaseru tugô kara Mizikasa ni Kagiri ga atte, taitei $L=15$ cm gurai yorimo mizikakuwa dekinai (mottomo, hizyôni tiisai Undô dake wo Mokuteki to suru Baai wa, sô to kagiranai). Sitagatte sore no $M''$ wa Tiisasa ni Kagiri ga aru. Kore no kekkwa, $m$ no Siki no Bunsi no uti

de, saigono Kô $4M''\frac{c^2r^2}{t^2a'^2\theta_0^2}$ ga mottomo ôkina Atai wo moti, nakano Kô $2M'\frac{r^2}{a'^2\theta_0^2}$ wa sore ni kurabereba tiisai ga, nao suterareru hodo dewa nai. Sikasi daiitino Kô $\frac{2M}{h^2}$ wa itizirusiku tiisai kara, kore wo sasioite kangaete sasitukae-nai. Yotte

$$m=\frac{\frac{1}{L^2}\left(M''+\frac{t^2}{2c^2}M'\right)N_0^2}{\frac{T^2q}{4\pi^2}N_0-1}$$

to tori, $LM''Tq\,\frac{t^2}{c^2}M'$ wo itteino mono to site, $m$ wo saisyôni suru $N_0$ wo motomereba,

$$\frac{T^2q}{4\pi^2}\frac{1}{N_0}-\frac{1}{N_0^2}=\max.$$

no Keisan kara

$$\frac{T^2q}{4\pi^2}N_0=2$$

wo eru. Yueni

$$N_0=\frac{2Lrc}{a't\theta_0}=\frac{8\pi^2}{T^2q},$$

$$m=\frac{1}{L^2}\left(M''+\frac{t^2}{2c^2}M'\right)N_0^2=\frac{1}{L^2}\left(\frac{8\pi^2}{T^2q}\right)^2\left(M''+\frac{t^2}{2c^2}M'\right).$$

Mata

$$K(1+\mu)=\frac{mqN_0}{4}=\frac{2\pi^2m}{T^2}.$$

Genzaino Sekkei dewa,

$$T=0\cdot07\text{ sec},\quad q=\frac{1\cdot7}{0\cdot1}\ \frac{1}{\text{sec}^2}$$

to totte,

$$N_0=947.$$

Mata Sisin wo, Atusa 0·15 mm, Haba Moto de 8 mm Sue de 0 no Aruminyûmu-ita de tukuru mono to mite $M''=9\cdot12$ gr.cm.$^2$ $t$, $c$ wa atoni aru Kandyô ni yotte $t=0\cdot6$ cm, $c=2$ cm, $M'$ wa gaisan 23 to totte keisansuruto,

$$m=40\text{ kgr},$$

$$K'(1+\mu)=16\cdot1\times10^7\ C.G.S.$$

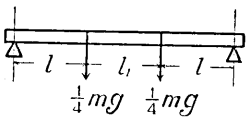
to naru.

## Omori wo sasaeru Bane no Sekkei.

**11.** Zyôgedô to Suiheidô ni taisite mattaku dôyôna Sôti wo tukurô to suruto, Omori no Omomi wo sasaeru ni Dansei-bô wo tukai, sore ga

ueni dasita to onazi $K$ no Atai wo motu yôni sureba yoi. Sosite kono Bô wa $mg$ no Tikara wo uketemo zyûbunni Dansei-no-Sakai no utini aru koto ga hituyô de aru.

Bô no Tawami wo tukau Bane de areba, Danmen ga ataete aru tokini, Bô no naka deno saidaino Tawami no itteino Atai ni taisite Tikara no Sayô-ten no Hen'i ga narubeku ôkii yôna Katati wo tukau ga yoi. Kono Imi de, Dai 4 Du no Katati no Sôti wo tukau koto ni suru. Konoyôna Bô wo nihon suiheini, tagaini suityokuni sôtisuru kara, onoonono Ten ni $\frac{1}{4}mg$ dutu kakaru mono to suru.



Dai 4 Du.

Bô no Haba wo $b$, Atusa wo $t$, $l\,l_1$ wo Du no yôni toruto, Omori no kakaru Ten no sagaru Taka wa, Dansei-keisû wo $\varepsilon$ to site,

$$x=\frac{\frac{1}{4}mg}{\varepsilon\frac{bt^3}{12}}\left(\frac{l}{3}+\frac{l_1}{2}\right)l^2=\frac{mg}{\varepsilon bt^3}\left(l+\frac{3}{2}l_1\right)l^2.$$

Ima Bô no Dansei-no-Sakai ni okeru Nobi wo $\lambda$, Tyôryoku wo $H=\lambda\varepsilon$ to sureba, Bô no Tyûô-bubun no Sitadura no Nobi wo

$$\frac{3}{2}\frac{mgl}{\varepsilon bt^2}=\frac{1}{f}\lambda$$

to si, $f$ wo 1 yorimo ôkiku, sikamo narubeku ôkina Kazu ni subeki de aru. Kore wo

$$\frac{bt^2}{l}=\frac{3}{2}f\frac{mg}{H} \qquad \text{.....(I)}$$

to kaku.

Mata kono Sôti ni tuite, onoonono Tikara no Sayô-ten ni taisuru $K$ wa

$$K=\frac{\frac{1}{4}mg}{x}=\frac{1}{4}\frac{\varepsilon bt^3}{\left(l+\frac{3}{2}l_1\right)l^2}.$$

Sitagatte maeno Setu no Owari ni eta $K$ no Kwankeisiki wa tugino Siki wo ataeru,

$$\frac{l^2\left(l+\frac{3}{2}l_1\right)}{bt^3}=\frac{\varepsilon}{4K}=\frac{\varepsilon T^2(1+\mu)}{8\pi^2 m} \qquad \text{.....(II)}$$

(I), (II), hutatuno Siki to maeni dasita $\mu$ no Dyôken ni kanau yôni, katu $f$ wo narubeku ôkiku suru yôni Bô wo sekkeisureba yoi.

Genzaino Sekkei dewa, $H=20\frac{\text{kgr}}{\text{mm}^2}$ to tori, mata $\varepsilon=2{\cdot}1\times10^{12}$, $T=0{\cdot}07$ sec, $m=40$ kgr to totta node, tugino yôni eranda,

$$l=13{\cdot}5,\quad l_1=9{\cdot}2,\quad b=3{\cdot}3,\quad t=0{\cdot}7\text{ cm}.$$

Kore de keisansuruto,

$$f=4{\cdot}0,\quad \mu=0{\cdot}35\,;$$

mata

$$K=11{\cdot}93\times10^7\,;$$

Omori no kakaru Ten no sagatte iru Taka wa 0·82 mm ni naru.

**12.** Suihei-hôkô de Omori wo sasaeru Bane wa, Omori no Omomi hodo ôkina Tikara de hatte oku hituyô ga nai kara, Dai 1 Du ni Tensen de simesita yôna Katati ni tukutte zyûbun de aru. Sosite, Zyôge-hôkô no Bane to dôituno $K$ wo motaseru. Soreyue, $b'$ $t'$ $l'$ wo mae to dôyôna Ryô to site,

$$\frac{\varepsilon b't'^3}{4l'^3}=K,$$

$$\frac{b't'^2}{l'}=6f\frac{F}{H},$$

to suru. Tadasi $F$ wa Bane no kaku Hazi wo hatte iru Tikara.

Genzaino Sekkei dewa tugino yôni eranda,

$$l'=7,\quad t'=0{\cdot}4,\quad b'=1{\cdot}22\text{ cm}.$$

$F=2$ kgr to sureba, $f=4{\cdot}65$ to naru. Kono $F$ no tameni Bane no Hazi no hikiyoserarete iru Taka wa 0·16 mm ni naru.

### Teko $S_1$ $S_2$ oyobi sonohokano Bubun no Sekkei.

**13.** Sisin no Hazi no Hure no Saidaigen (Ko no Nagasa) wo $D$ to sureba,

$$\sqrt{2}\frac{c}{t}\theta_0=\frac{D}{L},$$

mata Kwakudairitu no Kwankei kara,

$$\frac{2Lrc}{a't\theta_0}=N_0.$$

Korera hutatuno Dyôken ni kanau yôni $a$, $b$, $\left(a'=a+\frac{a^2}{b}\right)$, $\theta_0$, $r$, $c$, $t$ wo tekigini kimeru. Mata $\mu$ no Atai kara $Pp$ mo kimaru.

Genzaino Sekkei dewa,

$$N_0=947, \quad D=5, \quad L=15$$

wo kiteino mono to site, tugino Atai wo erabu koto ni sita,

$$a=4\cdot25, \quad b=9\cdot0, \quad (\text{sitagatte } a'=6\cdot26),$$

$$a\theta_0=0\cdot3, \quad c=2, \quad t=0\cdot6, \quad r=4\cdot18.$$

$(Pp+k\theta_0)\frac{r^2}{2a'^2\theta_0^3}=\mu K$ de, $k\theta_0$ wo tiisai mono to kateisite $Pp$ wo kandyôsuruto, $Pp=65900$ dyne × cm.

$p=1\cdot5$ cm to suruto, $P=44\cdot8$ gr no Omosa ni naru.

**14.** $S_1 S_2$ no Teko wo sasaeru Bane wa, Disin ni okoru saidaino Kasokudo $\alpha_1$ ni saisite, Omori ni sono Undô wo saseru ni taeru koto ga hituyô de aru. Kore niwa 45° ni katamuita Bane wo nihon kôsasite tukau koto ni suru. Sorede, ipponno Bane wa

$$\frac{1}{\sqrt{2}}\frac{1}{r}m\alpha_1$$

no Tikara ni taeru koto ga hituyô de aru.

$\alpha_1$ wo $g$ to tori, $r$ ni ueno Atai (4·18) wo toreba, ipponno Bane wa 7 kgr no Omori wo sasaeru koto ga hituyô de, tatoeba Haba 7 mm, Atusa 0·05 mm no Hagane-himo wo tukau to site yoi. Kono Hagane-himo wo, tawamu Bubun no Nagas ga $\sqrt{2}$ mm dake aru yôni sôtisureba $k\theta_0$ wa 7800 gurai ni natte $Pp$ ni taisite oyoso 9-bunno iti gurai ni ataru.

Hokano Renrakuyô oyobi Sasae no Bane mo doyô de,

$S_1 T_1$ no aidano mono, $S_2 T_2$ no aidano mono wa $\frac{1}{r}m\alpha_1$ ni,

Omori to $T_1 T_2$ to no aidano mono wa $m\alpha_1$ ni,

$T_1 T_2$ no Sasae no Bane wa $\left(1+\frac{1}{r}\right)m\alpha_1$ ni,

taeru koto ga hituyô de aru.

$S_1 S_2$ $T_1 T_2$ nado no Teko no Sasae ga onoono itten de nakute Bane ni natte iru tameni Siten ga yokoni ugoku koto no Eikyô wo kandyôsite miru ni, sore wo midikaku sae tukuru naraba Eikyô ga nai mono to mite yoi.

## Ondo no Eikyô.

**15.** Ondo-henkwa no tameni onoonono Bubun no Bôtyô ya Danseiritu no Henkwa ga okoru ga, kono Kikai de sono Eikyô wo tokuni eibinni kanzuru no wa,

(1) Omori no Omosa wo sasaeru Bane no Danseiritu no Henkwa to,

(2) $O T_1$ no aida, $O T_2$ no aida, $T_1 S_1$ no aida, $T_2 S_2$ no aidano Renrakusen no Bôtyô

de aru.

Omori no turiau Iti ga Bane no Danseiritu no Henkwa no tameni sagaru Ryô wa, Danseiritu no Henkwa no Ritu wo $\gamma$ to sureba, itido no Nobori ni tuki

$$\frac{mg}{4K}\times\gamma$$

de aru. Kore wo oginau niwa Bane no Sasae ni Sintyû wo tukau. Kono Sasae no Takasa wo $z$ to sureba,—Sintyû to Tetu to no Bôtyôkeisû wo sorezore $\alpha_S$ $\alpha_T$ to site,

$$z(\alpha_S-\alpha_T)=\frac{mg}{4K}\times\gamma$$

no Kwankei kara

$$z=\frac{mg}{4K}\frac{\gamma}{\alpha_S-\alpha_T}$$

ni toreba yoi. Nao Bane to Omori to wo tunagu Sen no Bôtyôritu to Tetu-imono no Bôtyôritu to no Sa no Eikyô mo, $z$ wo kagensuru koto ni yotte oginawareru.

Genzaino Sekkei dewa, $\frac{mg}{4K}=0\cdot82$ mm, $\gamma=\frac{1}{10000}$, $\alpha_S-\alpha_T=\frac{0\cdot7}{100000}$ to totte $z=1\cdot17$ cm ni tukureba yoi. Nao Bôtyôritu no Eikyô wo sukuu tameni, Sintyû no Takasa wo 3 cm gurai madeni nasi uru yôni sekkei-suru ga yoi to omowareru.

**16.** Omori to $T$ to $S$ to wo renrakusuru Sen (Hagane-himo) to Imono to ni Bôtyô no Sa ga aruto, $\theta_1$ $\theta_2$ ni hikakutekini ôkina Eikyô wo syôzuru. Sôti wo Migi-hidari taisyôni tukutte aru kekkwa, Sisin no Reiten niwa Eikyô ga nai ga, $\theta_0$ niwa Eikyô wo syôzuru.

Renrakusen no zentaino Nagasa wo $s$ to sureba, itido no Sa ni tuki $\theta_0$ no Kawari wa,—hutatu no Bôtyôritu wo $\alpha_1$ $\alpha_2$ to site,

$$\frac{a'}{2r}\delta(\theta_0^2)=\frac{a'}{r}\theta_0\delta\theta_0=s(\alpha_1-\alpha_2).$$

Sitagatte

$$\frac{\delta(\text{saidaino } X)}{\text{saidaino } X}=\frac{\delta\theta_0}{\theta_0}=\frac{rs(\alpha_1-\alpha_2)}{a'\theta_0^2}.$$

Genzaino Sekkei ni taisite, $s=20$, $\alpha_1-\alpha_2=\frac{1}{1000000}$ to kateisureba, Ondo no Sa 30-do ni yotte oyoso $\frac{1}{12}$ hodono Henkwa ni naru. Kono Henkwa wa warini ôkii keredomo, Kikai ga Disinkei no Yô wo nasu ueniwa sahodono Sasitukae wo syôzuru koto wa nakarô to omowareru.

Mosi Sôti ga taisyôni tukutte nakute, $s$ no Atai ga Ryôgawa de tigau tokiniwa, Turiai no Iti ga Ondo ni yotte kawari, toriatukaizyô Tugô ga warui de arô to omowareru.

## Sisin no Hazi no Masatu.

**17.** Sisin no Hazi no Masaturyoku wo $R$ dyne to sureba, Omori ni sayôsuru Tikara no $N_0R$ dyne madewa Sisin wo ugokasu ni tarinai. Kono Tikara wa Kasokudo ni oite,

$$\frac{N_0R}{m} \quad \frac{\text{cm}}{\text{sec}^2}$$

ni ataru.

Osoi Disindô no hizyôni tiisai Kasokudo wo sirusaseru niwa, $N_0$ wo ôkiku suru ($T$ wo ôkiku suru koto ga Tugô ga warui Baai) koto ga hituyô de aru noni, ueno Ryô wo kaette hanahada tiisaku suru koto wo yôsuru kara, kono Mondai wa yôinaranai Konnan wo syôzuru. Kono-yôna Baai ni kokoromite yûkô ka to omowareru hitotuno Hôhô wa, Omori ni Onsa wo kuttukete oki, Denryû wo tukatte tuneni sore wo sindôsasete oku. Sô sureba, Sisin no Hazi wa tuneni aru tiisai Haba wo yûsuru Kyokusen wo egaki, Haba no Tyûô-no-Sen wa Masatu no Eikyô wo ukenai Hari no Iti wo simesu wake ni naru. Tadasi kono An no Yosiasi wa zittini kokoromite minakereba tasikaniwa ienai.

Genni sekkeisite iru Kikai dewa, ueni sirusita Kasokudo wa hanahada tiisakute nanno Konnan womo syôzinai.

## Hokano Seibun wo sirusu Bubun no Eikyô.

**18.** Omori ga arù Hôkô ($x$-Hôkô) ni sukosi uturuto, ueni simesita Tikara ($K$ ni yoru mono, $P$ ni yoru mono, $k$ ni yoru mono) no hokani, hokano Hôkô ni Omori wo sasaete iru Tikara ga $x$-Hôkô ni Seibun wo syôzite, $KP$ nado to dôyôna Sayô wo syôzuru. Kono Sayô wa, Suiheidô ni taisuru Dyûryoku no Bunryoku ni oite itiban ôkiku arawareru.

Omori wo turu Sen no tawami-yasui Bubun no Nagasa wo $L_1$ to si, $x$ to suityokuna Suihei-hôkô ni Omori to Bane to wo tunagu Sen ni kwansuru dôyôna Nagasa wo $L_2$ to si, Kiroku-bubun ni renrakusite iru Sen ni kwansuru dôyôna Nagasa wo $L_3$ to sureba, korerano Sen wo tôsite Omori ni sayôsuru $x$-Hôkô no Tikara wa

$$-\left(mg\frac{x}{L_1}+4F\frac{x}{L_2}+\frac{4Ppr}{a'}\frac{x}{L_3}\right)$$

de aru. Kore wo, maeni dasita, $\varphi$ no tiisai Baai no Tikara

$$4Kx+2(Pp+k\theta_0)\frac{r^2}{a'^2\theta_0^3}x=4K(1+\mu)x$$

ni kuraberuto, $4K(1+\mu)=mqN_0$ no Kwankei ga aru kara,

$$\frac{\frac{mq}{L_1}+\frac{4F}{L_2}+\frac{4Ppr}{a'L_3}}{mqN_0}$$

no Hi ni naru. Kono naka de omona Kô wa

$$\frac{g}{L_1qN_0}$$

de, genzaino Sekkei dewa $\frac{1}{160}$ guraino mono de aru.

## Dimen-keisya no Eikyô.

**19.** Dimen no Keisya wa Kikai no Kiroku no ue de, suiheino Disin to dôyôna Eikyô wo syôzuru koto wa, koremadeno Disinkei nimo aru ga, Kasokudo-disinkei nimo sore ga aru.

Dimen no Keisya no Kaku ga $\varepsilon$ de aru to sureba, Kikai wa $\varepsilon g$ dakeno Suihei-kasokudo wo kirokusuru.

Ima kokoromini, onazi $\varepsilon$ no Keisya ga atta Baai no Turiai no Iti ni tuite, ueno Eikyô wo Suihei-sinsi ni taisuru Eikyô ni kurabete miru.

Suihei-sinsi no Diku no Entyokusen ni taisuru Katamuki wo $i$, Omori no Dyûsin ga Diku kara hedatatte iru Kyori wo $D$ to sureba, Suihei-sinsi wa $\varepsilon$ no Keisya wo

$$\frac{\varepsilon}{\sin i}D$$

dakeno Dimen no Hen'i to dôyôni kirokusuru. Suihei-sinsi no Ziko-sindô no Syûki wo $T_H$ to sureba,

$$\frac{D}{\sin i}=\frac{gT_H^2}{4\pi^2}$$

no Kwankei ga aru kara,

$$\frac{\varepsilon D}{\sin i}=\frac{\varepsilon gT_H^2}{4\pi^2}$$

Ima 2-syuruino Disinkei ga onazi Teido no Disin wo kirokusuru yôni tukutte aru mono to site kuraberu ni, sono Disin no Syûki wo $T_D$, Sinpuku wo $A$ to sureba, Suihei-sinsi wa $A$, Kasokudo-disinkei wa $\frac{4\pi^2}{T_D^2}A$ wo onazi Teido ni kirokusuru wake de aru. Korera ni, ueno Keisya no Eikyô wo kuraberuto,

Suihei-sinsi de $\frac{\varepsilon gT_H^2}{4\pi^2A}$ bai,

Kasokudo-disinkei de $\frac{\varepsilon g}{\frac{4\pi^2}{T_D^2}A} = \frac{\varepsilon g T_D^2}{4\pi^2 A}$ bai

de aru. Hutatu no Hi wo toreba, Kasokudo-disinkei ni arawareru Eikyô wa Suihei-sinsi no sore ni kurabete

$$T_D^2 : T_H^2$$

ni naru. $T_H$ wa tûzyô $T_D$ ni kurabete hanahada ôkiku tukutte aru kara, Kasokudo-disinkei dewa, Suihei-sinsi yoriwa Dimen-keisya no Eikyô wo ukeru koto ga yohodo tiisai to ieru.

Tadasi, Keisya no Henkwa wa Suihei-sinsi dewa tadatini Sisin ni arawarenakute, Kasokudo-disinkei dewa tadatini arawareru to iu Sa ga aru. Mata, Suihei-sinsi dewa kotonaru $i$ ya $D$ wo yûsuru Kikai wo tukaeba, Dimen no Hen'i to Keisya to wo wakeru koto ga dekiru kamo sirenai ga, Kasokudo-disinkei dewa, sore no seisituzyô kara akiraka de aru tôri, Keisya to Suihei-kasokudo to wa donna Kikai nimo mattaku dôtôna Sayô wo teisuru mono de aru.

Kono Ten wa Kasokudo-disinkei no Tansyo de aru ka to omowareru keredomo, Disin no saini Dimen ni koteisite iru Buttai, tatoeba Tatemono nado ga yahari Keisya to Suihei-kasokudo to kara mattaku dôtôna Sayô wo ukeru koto wo kangaereba, kaette kono Seisitu no tameni Tugô ga yoi Ten mo aru ka to omowareru. Tonikaku Kono Kikai no Sido ga Kwako ni kwankei-naku Maisyunzi ni genzaisurù arù Ryô wo simesite iru koto wa Kiroku wo Mokuteki to suru Kikai tosite musiro yoi Seisitu to iubeki de aru.

Genzai sekkeisite iru Kikai dewa, Hito no kanzuru Disin wo Mokuteki to site iru kara Keisya wa mattaku mondaigwai da to itte yoi. Sore ni kakawarazu, ueni nobeta Koto wa Kasokudo-disinkei no Seisitu tosite itizirusii Koto de aru kara, tati-itte ronzita no de aru.

### Ziko-sindô no Eikyô.

**20.** Gwanrai, Toki ni taisuru Kasokudo no Henkwa wa, Hen'i ya Sokudo no sore no yôni yôyôna Imi wo motanai kara, Kasokudo-disinkei dewa, komakai Ziko-sindô ga mazitte itemo Sasitukae ga nai rasiku omowareru. Sikasi, Ziko-sindô no Syûki ga Disindô no Syûki ni kurabete hanahada tiisaku nai yôna Baai niwa, Ziko-sindô wo nibumeru Sôti ga hituyôni naru de arô.

Genzai sekkeisite iru Kikai dewa, Sisin no Diku no sitani, konoyôna Nibume-sôti wo toritukeru koto mo guwaiyoku dekiru. Kore no Hituyô no Arunasi wa syôraino Kenkyû ni yotte sadameru.

## Hito no kanzinai Disindô wo kirokusuru Kikai.

21. Syûki ga sû-byô ni wataru yôna yowai Disin no Kasokudo wo kirokusuru ni, ueni dasita Siki ni sitagatte, Syûki wo onazi Teido ni tukurô to suruto, sûhyaku-ton matawa sûsen-ton no Omori ga hituyôni naru. Sorehodo ôkiku nai Omori de tukurô to suru niwa,

(1) Kôgakuteki-Kiroku no Hôhô wo toru ga hitotuno Hôhô de aru. Kore wa $M''$ wo tiisaku site, sitagatte $m$ wo tiisaku si, mata Masatu no Eikyô wo manugareru Rieki ga aru. Kore niwa, daitaino Katati wo genzai sekkei no mono to dôyôni tukutte guwaiyoku dekiru. Mata

(2) Ziko-sindô no Syûki wo ôkiku si, dôzini Nibume no Sôti wo soe Masatu no Eikyô wo manugareru Kuhû wo suru no mo hitotuno Hôhô de aru.

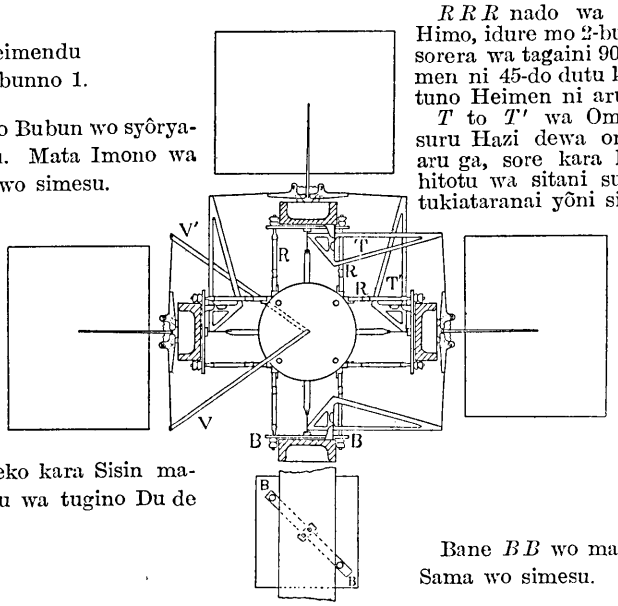
Korera wa syôraino Kenkyû ni matubeki mono de aru.

## Genzai sekkei no Kikai.

22. Genzai sekkeisite iru Kikai wa tugini soeru Ryakudu (Dai 5 Du oyobi Dai 6 Du) ni aru yôna Katati wo nasite iru. Sore no Yôbu no Ryô wa ueni tokorodokoro ni kakageta tôri de, Tetu-imono wa Mae-usiro, Migi-hidari onoono 42 cm, Takasa 41 cm, Tyûô ni aru Omori no

Heimendu 12-bunno 1.

Itiban ueno Bubun wo syôryakusite simesu. Mata Imono wa Hasira dake wo simesu.




$R\,R\,R$ nado wa usui haganeno Himo, idure mo 2-bubun kara natte, sorera wa tagaini 90-do, Du no Heimen ni 45-do dutu katamuita hutatuno Heimen ni aru.

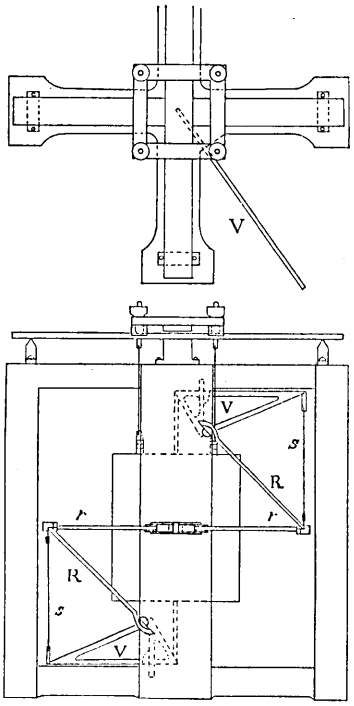
$T$ to $T'$ wa Omori ni renrakusuru Hazi dewa onazi Takasa ni aru ga, sore kara hitotu wa ueni, hitotu wa sitani sukosi katamuite tukiataranai yôni site aru.

$V\,V'$ no Teko kara Sisin madeno Renraku wa tugino Du de sireru.

Bane $B\,B$ wo mae kara mita Sama wo simesu.

Dai 5 Du.

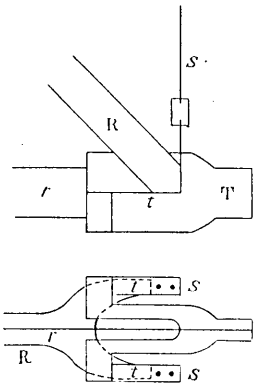
Kikai no ueno Bubun wo ue kara mita Du




Zyôgedô wo sirusu Bubun wo simesu tameni maeno Du no hidarino hô kara mita Du.

Omori no Zyôgedô wa *V* ni yotte *s*-sen no Zyôgedô wo syôzi, mata Teko *R* ni yotte *r* no Suiheidô wo syôzi, sore ga hakano Seibun to dôyôni kirokusareru.

*s*-sen to *r*-sen to no Renraku wo simesu Du




(Sita kara mita Du)

*s*-sen no Sitahazi to R-bô no Hazi to wa hutamatuni nari, R niwa *s* to suiheina Hagane-himo *t* to ga kuttuki, kono *t*-kire no Hidarihazi wo torituketa *T* ni *r* no Himo ga tukete aru.

Dai 6 Du

Omosa 40 kgr, migino hô to maeno hô ni Suiheidô wo sirusu Sisin, hidarino hô ni Zyôgedô wo sirusu Sisin ga atte, onoono betubetuno Taiko no ueni hudan Kiroku wa suru. Taiko no Kwaiten wa, maihun 9 cm gurai ni nasi, ittyûya no Kiroku wo onoonono Seibun ni itimaino Kami ni kakaseru.

**23.** Kono Kikai wo tukuri katu sore no Hatarakiburi wo kensasuru tameniwa, Huzoku-kikai (Taiko, Tokeizikake nado) wo awasete oyoso 500 En no Hiyô wo yôsuru Mikomi de aru.

## *21. The Construction and Study of an Acceleration Seismograph.*

By Takuro TAMARU.

1. *The Object of the present Seismograph.* It has been too difficult for the hitherto built seismograph to calculate the acceleration minutely from its record of displacement or velocity of the earth's movement. So I think it will be very usefull to construct a seismograph capable of recording acceleration directly. The hitherto one, besides, has been nearly unstable in arrangement, incapable of recording the three dimentional movement by a single mass, full of obstruction on the proper oscillation, deflection of the index outside of the limit of the recording paper as the result of too great amplitude of oscillations and so on. The new seismograph will save all these defects.

2. *The General Structure.* It is composed of the main frame, the pendulum, and three sets of drums and indexes. The cast iron frame has the width and length of 42 cm., the height of 41 cm. The single mass of pendulum, which finds itself in the centre of frame has 40 kg. In the right, and in the front, we find two indexes which register the horizontal movement, and in the left, one which records the vertical movement. Each index touches on its respective drum, which rotates with the speed of 9 cm. per min., and draws the diagram during the whole day on a sheet of paper in each component. It will be costed about 500 Yen with its accessories (drums, clockworks, etc.).

3. *The General Characteristics.* The special arrangements and the general characteristics derived therefrom are the followings:

(i) Recording of Acceleration. It is our fundamental idea attaining the aimed record of acceleration, to arrange a pendulum with fairly great mass so as to move similarly as the earth, and to record the force between the pendulum and the frame sustaining it. This force, which is necessary to make the pendulum move samely with the earth, has a direct proportion to the acceleration of the earth's movement. If we aim only to record this force, we may well use strong springs in every direction—upwards and down wards, east and west, north and south. The deformation of the spring is therefore in proportion to the kinematic changes of the motion of the pendulum. The record thus obtined shows the acceleration. We will not, however, simply use a strong spring in holding the pendulum, for the sake of the fifth characteristics.

(ii) It can register the three dimentional movement using a single pendulum being connected with the same arrangement for each component.

(iii) It has a very stable equilibrium while the hitherto one has been nearly unstable.

(iv) Less influence of proper oscillation and thermal changes. It seems for an acceleration seismograph to have minute proper oscillations mixed within. It is, however, necessary to lessen the proper oscillation, when the period of the proper oscillation is not so small compared to that of the earth's shocks. This apparatus will have a special arrangement under the holder of the index, to absorb the proper oscillation. To lessen the thermal influence which may be given to the spring, the brass holding of the spring, the wire connecting the spring and the pendulum, the cast iron frame etc., we can make a preparatory calculation of the expansion coefficient of their material, and consequently neglect the thermal deformation of the apparatus as a seismograph.

(v) In order to get rid of the deflection of the index outside of the recording paper as the result of too great shocks, it has a special arrangement to restrict the index mo-

ton within a certain limit. In other words, we do not simply use strong springs in holding the pendulum, but the degre of deflection of the index is made to lessen according as the force increases, (the force necessary for making it movable samely with the earth) and when this force increases more and more, the index approches near to a certain position asymptotically in a cetain direction.

(vi) To lessen the effect of the friction at the end of the index when we register very small acceleration of a slow earth movement, we may efficiently attempt to join a tuning fork with the pendulum, which is constantly vibrated by electric current. Thus the end of the index always draws a curve having a certain width, and the middle line of the width will show the position of the index free from the frictional effects. The validity of this plan, however, depends on experiment.

(vii) The acceleration seismograph sufferr less influence of the earth's tilting than the horizontal pendulum. Besides, the tilting appears enormously in the index in the latter, while it appears directly in the former. The tilting and the horizontal acceleration make entirely same action in the nature of the acceleration seismograph. But this is not the defect of this apparatus Considering that in case of earthquake the body fixed on the earth (e.g., a building) also suffers the same action from tilting and horizontal acceleration. We may, therefore, neglect the tilting motion of the present apparatus as to be applied to every thing.

To make a record of feeble earthquakes having the period of several seconds we will need a pendulum of the weight several hundred or several thousand kgs. Else, we may either take a method of optical recording, or make the period of proper oscillation great, therewith connecting an arrangement which lessens the influence of friction. All these I hope for the future study.