No. 1.

(English abstract from the Japanese original)

An Instrument to measure the Direction and Speed of Wind relative to an Aeroplane.

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This instrument makes use of the dependence of the pressure at any point of a cylinder against which the wind blows, on the azimuth of the point measured from the direction from which the wind comes, and records a *difference or differences* of pressure for different azimuths. The actual cylinder has a diameter 1.24 cm., and has two or three rows of three or four small holes each, the rows being parallel to the axis of the cylinder. The space inside the cylinder is separated longitudinally, so that each row of holes has its own space from which a side tube allows connection with a pressure measuring instrument.

My first instrument had a tube with two rows of holes, and as the pressure-meter an ordinary aneroid with certain modifications. It was intended to measure directly the *angle of side-slip* when the aeroplane makes a horizontal turn or a steep descent with side-slip, the velocity of the aeroplane relative to the air being assumed as known. This instrument was tried on an aeroplane "Avro" in flight, and was found to work as satisfactorily as could be expected.

When the azimuthal angle is considerable, however, the knowledge of the magnitude of velocity, as measured by a fixed pitot-tube can not be said to be exact enough. So I proceeded to work out the principle of a registering instrument, from which the direction and velocity of the wind (in a longitudinal plane fixed to the aeroplane, which may be, in the normal position of the latter, either horizontal or vertical) relative to the aeroplane can be determined. The range of direction covers an angle of 120°; e.g. when set for up-and-down angles, for any angle of attack between −20° and 100°. This will include the case an aeroplane recovers suddenly from a vertical dive.

The instrument registers directly *two differences* of pressure, P_1 and P_2, of *three* rows of holes. The middle set of holes B makes an angle of 30° with those on the sides A and C. Thus,

$$P_1 = p_A - p_B, \quad P_2 = p_B - p_C.$$

The method of registering is the same as in an ordinary barograph. The inside spaces of two piles of elastic boxes are separately connected to the sets of holes on the sides A and C, while the chamber of the barograph made airtight is connected to the middle set B.

A preliminary examination with tubes of diameter 0.91 and 1·27 cm. and wind velocity 18.4 and 25·8 m/sec. resp. in a wind tunnel gave the "reduced" negative pressure pr as a function of azimuth φ, as shown in fig. 10 (p. 11) and Table I (p. 12), this being

the value of p measured from that for $\varphi=0$, and where the "amplitude" i. e. the difference between the maximum and minimum of pressure is taken as unity; thus, $p_r=\frac{p-p_0}{\text{ampl.}}$

From this, denoting the azimuth of B by θ, I have calculated the numbers for

$$\frac{P_1}{\text{ampl.}}=\frac{p(\theta-30°)-p(\theta)}{\text{ampl.}}=p_r(\theta-30°)-p_r(\theta),$$

and

$$\frac{P_2}{\text{ampl.}}=\frac{p(\theta)-p(\theta+30°)}{\text{ampl.}}=p_r(\theta)-p_r(\theta+30°),$$

as shown in the columns (1) and (2) of Table II (p. 13).

On calculating $\sqrt{2(P_2-P_1)^2+.95(P_2+P_1)^2}$ /ampl., I find values nearly equal to unity for all values of θ (column (7) of the same Table); and further, $(P_2+P_1)/(P_2-P_1)$ and $(P_2-P_1)/(P_2+P_1)$ are found to be well suited for determination of θ (columns (8) and(9)).

Hence, as the values of P_1 and P_2 are registered by the instrument, the values of θ and ρV^2 (ρ, the density of air; V, the velocity of wind) can be found thus:—

$$\theta=f_1\left(\frac{P_2+P_1}{P_2-P_1}\right)=f_2\left(\frac{P_2-P_1}{P_2+P_1}\right)$$

by making use of Table III or fig. 12 (pp. 16, 17).

$$\rho V^2=k\sqrt{2(P_2-P_1)^2+.95(P_2+P_1)^2}\times F(\theta),$$

where k is a constant giving the ratio ρV^2/amplitude, and $F(\theta)$ is the reciprocal of the numbers under (7) of Table II and is given by Table IV and fig. 13 (p.17). k has, so far as I can see with the small wind tunnel at my disposal, a value near unity; its more exact value has still to be determined.

The approximate relations

$$\rho V^2=k\sqrt{2(P_2-P_1)^2+.95(P_2+P_1)^2}$$

$$\theta=\cdot 441\tan^{-1}\left(\cdot 689\frac{P_2+P_1}{P_2-P_1}\right)$$

suggest a graphical method of finding ρV^2 and θ from P_2-P_1 and P_2+P_1. If we have a diagram provided with lines of constant P_2-P_1, P_2+P_1, θ and ρV^2 (or V, if ρ is considered constant) as in fig. 14 (p. 19), we can read at once from it the values of θ and ρV^2 (or V) corresponding to any set of values of P_2-P_1 and P_2+P_1.

They further suggest the possibility of an instrument which gives *directly* the values of V (for a given ρ) and θ.

If we have two such instruments, one of which has its cylinder vertical and the other horizontal and transverse, we get four numbers, which are equivalent to the three component velocities of the wind, the forward velocity being given separately from each instrument and serving as a check.

For use in a fixed place, as in a wind tunnel, we can use along with the cylinder with rows of holes, one or two water manometers, instead of the aneroid or the barograph.

Dai 1 Gô.

(Taisyô 10 n. (1921) 2 gwatu hakkô.)

Hikôki ni taisuru Kaze no Hôkô to Hayasa wo kirokusuru Kikai.

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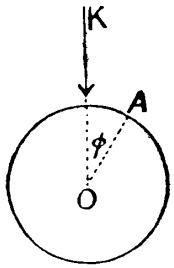
Dodaino Kangae.

Kokoni noberu Kikai wa, *Marubasira ni Kaze ga ataru tokini, sore no iroirona Ten ni okeru Aturyoku ga Ten no Iti ni yotte tigau* koto ni motoduite, Hikôki ga ukeru Kaze no Hôkô to Hayasa wo siru Mokuteki ni kuhûsita Kikai de aru.

Tidimanai kwanzenna Ryûtai ga Marubasira ni suityokuni atatte, sore no usiro made mawatte nagareru Baai niwa, Marubasira ni suityokuna Heimen de Kaze no Hôkô kara φ dake mawatta tokorono Marubasira no ueno Ten A ni okeru Ryûtai no Sokudo wa

$$v=2V\sin\varphi,$$



Du 1.

Aturyoku wa

$$p=p_0-\frac{1}{2}\rho v^2=p_0-2\rho V^2\sin^2\varphi$$

de aru. Tadasi, V wa Marubasira no Eikyô no nai Tokoro ni okeru Kaze no Hayasa, p_0 wa $\varphi=0$ no Ten ni okeru Aturyoku de aru. Sitagatte, hutatuno Ten A, B ni okeru Aturyoku no Sa wo P to sureba,

$$P=p_A-p_B=2\rho V^2(\sin^2\varphi_B-\sin^2\varphi_A)$$

ni naru. A to B to ni tiisana Ana wo akete oite, soko no Aturyoku wo hikakusuru to sureba, $\varphi_B - \varphi_A = \alpha$ ga kimatta mono de aru kara,

$$P = 2\rho V^2\{\sin^2\varphi_B - \sin^2(\varphi_B - \alpha)\}$$

wo kwansokusureba, ρV^2 ga sirete iru Baai ni, φ_B wo siru koto ga dekiru.

Mata, mohitotuno tiisana Ana C wo totte dôyôna Ryô P' wo B to C to ni tuite hakareba, $\varphi_C - \varphi_B = \beta$ to suru tokini,

$$P' = p_B - p_C = 2\rho V^2(\sin^2(\varphi_B + \beta) - \sin^2\varphi_B)$$

to naru kara, hutatuno Kwansoku kara ρV^2 to φ_B to wo siru koto ga dekiru.

Zissaino Baai niwa, Kûki no Undô ga ueno Riron no yôni yukanai kara, ueno Siki wo sonomama tukau wake niwa yukanai. Sikasi, p no φ ni taisuru Kwankei wa Zikken ni yotte kimeru koto ga dekiru kara, Daitai ni oite ue to onaziyôna Kandyô ga dekiru ni sôinai.

Kôre ga kono Kikai wo tukuru ni tuiteno dodaino Kangae de aru.

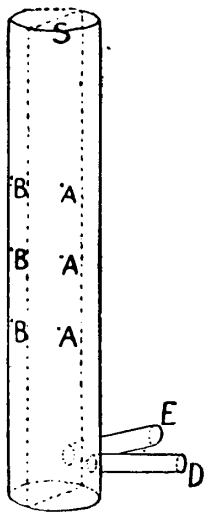
I. Yoko-suberi no Kakudo wo hakaru Kikai.

Hazime watasi no kangaeta no wa, Hikôki ga Hôkô wo kaeru tokini, matawa Yokosuberi de kyûni oriru tokini, *Kaze ga Syômen kara ikura yokoni katamuita Hôkô kara kuru ka* wo miru tameno Kikai de atta.

Kazeuke-kuda.

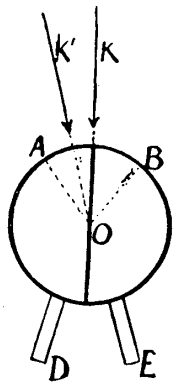
Kono Mokuteki ni Du 2 no yôna Kuda wo tukutta. Kono Kuda wa Ryôhasi ga todite atte, nakano Basyo ga tateno Ita S de hutatu ni sikitte aru. AAA to BBB to wa sorezore Kuda no Diku ni heikôna Iti ni aketa tiisana Ana (Tyokkei oyoso 1 mm.) de, Sikiri-ita no Ryôgawa no Basyo ni wakarete tuduite iru. D to E wa hosoi Kuda de, yahari Sikiri-ita no Ryôgawa no Basyo ni tuduite iru.

Kaze ga A to B to no mannakano Hôkô K (Du 3) kara kureba,



Du 2.

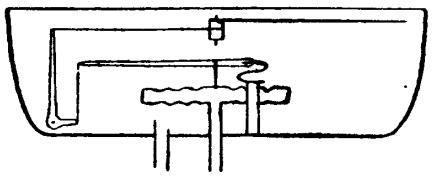
A to *B* ni okeru Aturyoku ga hitosii. Sikasi, Kaze ga *K'* no yôna katamuita Hôkô kara kuruto, *A* to *B* ni okeru Aturyoku ga tigau kara, *D* to *E* kara Aturyoku wo kuraberu Kikai e renrakusite okeba, sono Kikai ni arawareru Aturyoku no Sa de *K'* no Hôkô, sunawati Kaze ga Syômen kara ikura katamuite kite iru ka ga wakaru. Tadasi, Kaze no Hayasa wa hokano Hôhô——tatoeba Pitot-kwan de——sirete iru mono to suru.



Du 3.

Aturyokukei.

Aturyoku wo kuraberu no ni,—Hikôki no ue dewa Ekitai no Aturyokukei ga tukaenai kara—hutûno Aneroido-seiukei ni Te wo irete tukatta ([1]). Hutû sinkûni site aru Namigata-bakò ni Ana wo akete Kuda wo toritukete, sore wo *D E* no utino hitotu ni renrakusita. Mata, Aneroido no Sotobako wo Kûki no moranai yôni si, sore ni Kuda wo tukete *D E* no nokorino Kuti ni tunaida. Nao, hutûno Aneroido dewa Kanzi ga nibu-sugiru kara, narubeku eibinni Hari no ugoku yôni, Namigata-bako wo sasaete iru tuyoi Bane wo yowai mono ni torikaeta. Sore no kekkwa, Seiukei no Suigin 1 cm. dakeno Domori ga Midu no Hisira 5.68 cm. ni sôtôsuru yôni natta.



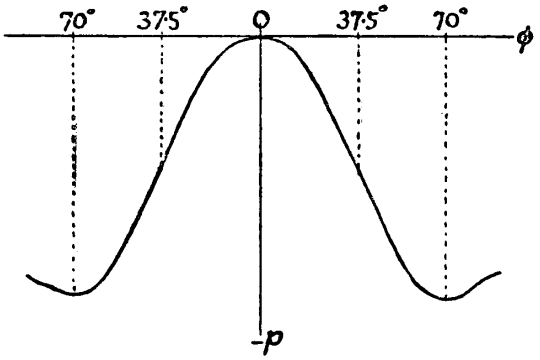
Du 4.

Ana no aidano Kakudo.

Nao, Hataraki wo dekirudake eibinni suru niwa, Kaze-uke-kuda no

([1]) Hûtô no naka no yôna ugokanai Basyo de tukau niwa, Ekitai no Aturyokukei wo tukau koto ga dekiru no wa motiron de aru.

Ana no aidano Kaku (Du 3 no AOB) ga Mondai de aru. Kono Mondai wo kimeru tameni, tiisai Ana A wo hitotu aketa Kuda wo Hûtô ni, Kaze wo suityokuni ukeru yôna Iti ni torituke, Kaze no Tuyosa wo kaenaide, Kaze K to OA to no aidano Kaku φ (Du 1) wo iroironi kaete, kono Kuda no nakano Aturyoku wo——nanameni sita Ekitai-aturyokukei de sotono Kiatu ni kurabete——hakatta Sore no Kekkwa wa Du 5 (1) no yôna mono de. $-p$ no Saidai ga $\varphi=\pm 70°$ hen, Saidai to Saisyô no mannakano Aturyoku wa $\pm 37.5°$ hen ni atta. Kono 37.5° hen ga p no Kawarikata no itiban kyûna Tokoro de aru kara, kore no nibai 75° wo Kaze-uke-kuda no Ana no aidano Kaku AOB ni toru koto ni sita.



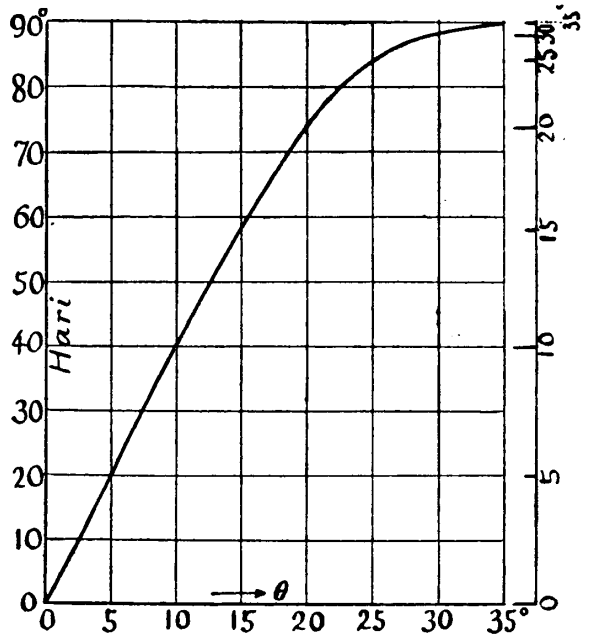
Du 5.

Kakudo no Domori.

Mohitotu nokotte iru Mondai wa, Aneroido no Hari no Iti to Kaze no Muki (Du 3 no $KOK'=\theta$) to no Kwankei de aru. Hari no Hure wa Aturyoku no Sa ni hireisuru kara, Du 5 no Kyokusen kara $p(37.5°-\theta)-p(37.5°+\theta)$ wo keisansureba, kore ga θ ni taisuru Hure ni hireisuru. Du 6 wa konoyôni keisansite hiita Kyokusen de aru ga, θ no 0° kara 10° madeno aida wa mattaku Tyokusen de aru. Du 6 no Hidarigawa ni kaite aru no wa, Kaze no Hayasa 30 m/byô ni taisuru Hure no Kakudo de aru. Kore wa tugino yôni site kimeta mono de aru. Hûtô no nakani Kaze-uke-kuda wo sikakete, Kaze wo atete 10° no θ ni taisuru Aneroido no Yomi wo hakatta. Konotoki no Kaze no Hayasa wo Pitot-kwan de hakattara 33.8 m/byô de atta kara,

(1) Kono Zikken dewa, Kuda ni koteisita Hari ga φ no Domoriita no Reiten wo sasu tokini tadasiku $\varphi=0$ de aru towa ienai; sunawati 0° no Naosi ga aru. Kono Koto wa notini noberu. Koko dewa kono Naosi wa yôyô de nai.

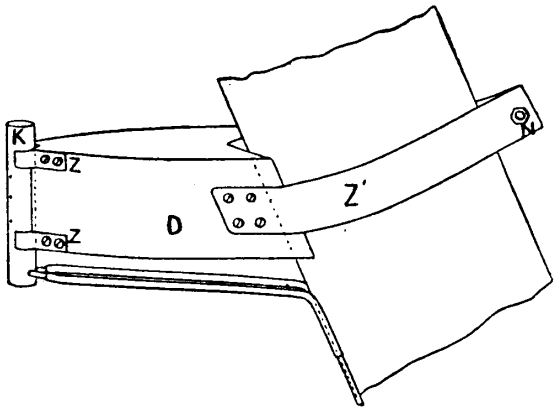
Aneroido no Yomi ni $\left(\frac{30}{33.8}\right)^2$ wo kakete, 30 m/byô no Baai ni hiki-naosita. Sono Kazu ga tyôdo Seiukei-domori no 2.00 cm., Kakudo ni site tyôdo 40° ni atatta. Sore-yueni, Kaze no 10° kara utino Katamuki wa,—— Hayasa ga 30 m/byô no Baai ni——4-bai ni natte Hari no Hure ni arawa-reru koto ni natta no de aru. Sikasi, motto ôkina Katamuki ni taisitewa Hari no Ugokikata ga sukunaku natte, 30° to 35° to dewa 1.6° sika kawaranai. Du 6 no Migigawa ni kaita no wa, Kaze no Katamuki (θ) wo tyokusetuni Aneroido no Ban ni kakikonda Domori de aru.



Du 6.

Hikôki ni okeru Zikken.

Konoyôni tukutta Kikai wo zissaini tukatte miru tameni, Tokorozawa no Rikugun Kôkûgakkô ni otanomi sita kekkwa, Iba Taii (notini Syôsa) ga *Avro* ni toritukete tonde kurerareta.



Du 7.

Du 7 wa Kazeuke-kuda no Toritukekata wo simesu. Kazuke-kuda *K* wo, Ki de tukutta Dai *D* ni nedituketa tiisai Kanagu *Z* de hasami, Daigi

D wa, sore ni torituketa betuno Kanagu *Z'* de Hikôki no Hasira—Migigawa no maeno Sotobasira—wo hasande Nedi *N* de kataku simetukete torituketa. Kono Toritukedokoro kara Dôzyôsya no Zaseki made akaganeno hosoi Kuda (Utinori 3.5 mm.) wo nihon, Hasira to Tubasa no Maeberi wo tutawarasete hatta. Sore to Kazeuke-kuda no sitani dete iru hutatuno Kuti to no Renraku, oyobi sore to Aneroido no hutatuno Kuti to no Renraku wa mina dyôbuna Gomukuda de sita.

Dôzyôsya tosite saisyo Iwamoto Gisi notini watasi ga notte, Aneroido wo Hiza ni nosete oite sore no Hatarakiburi wo mita. Sore no kekkwa, kono Kikai ga sôtôni yoku hataraku koto, kotoni *Kaze no Muki no Henkwa ga zyûbun tebayaku Hari no Undô ni arawareru* koto ga tasikamerareta.

Kyûna Kwaiten no Baai ni, tokiniwa 7–8° made no Katamuki de Kaze wo ukeru koto ga atta. Mata Yokosuberi de kyûni oriru tokiniwa, Aneroido no Hari ga Katamuki no Kaku 35° made môketa Domori (Domori-ita no ue de 90°) no soto made mawatta (1). Kotoni omosirokatta Koto wa, Yokosuberi de orite kita notini, Hikôki wo tairani naosite tonde iru tokini, Katamuki ga 0° wo simesanaide nagai aida 7–8° no Katamuki wo simesite ita. Kore wa tabun, Hikôki no yokono Undô ga Kwansei no tameni nokotte ita no de arô.

Ueno Zikken wa Rikugun Kôkûgakkô no Tôkyokusya, nakademo Iwamoto Gisi to Iba Syôsa no Gokôi ni yotte dekita no de, kokoni sorerano Katagata ni atuku Orei wo môsinoberu.

Mottomo sugureta Gizyutu wo motte orareta Iba Syôsa ga sononoti hokano Hikôki de tonde orareru aidano Dekigoto no tameni nakunarareta koto wa makotoni osimubeki itamasii Koto de aru. Sikamo, sono Ori ni mottomo otituita isamasii Hataraki wo sareta koto wa oosii uruwasii Saigo tosite wareware ni hukai Kandô wo ataeta Koto de aru. Watasi ni tottewa, Syôsa no Osewa ni natta kono Kenkyû no Kakimono wo Syôsa ni miseru koto no dekinai no wa kotoni zannenna Sidai de aru.

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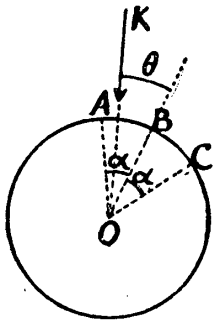
(1) Kore wa Sokudo ga 30 maibyô-mêtoru yorimo ôkikatta tame to omowareru.

II. Kaze no Hôkô to Hayasa wo Kirokusuru Kikai.

Ueni nobeta Kikai dewa, Hôkô no hakareru Kuiki ga migi hidari awasete 60° gurai de aru ; mata Kûki ni taisite Hikôki no susumu Hayasa ga sirete iru to kateisite, Kakudo wo hakaru koto ni natta iru. Katamuki no Kaku ga ôkiku naruto, ueno Kikai dewa Kuiki ga tarinai bakari de naku, Syômen ni mukete koteisite aru Pitot-kwan ga tadasii Hayasa wo simesanai Ten karamo, Hôkô ga tasikaniwa wakaranaku naru. Tatoeba, Kazeuke-kuda wo suiheini okeba, uesitano Heimen ni okeru Kaze no Katamuki ga sireru wake de aru ga, Hikôki ga Sakaotosi de ôkina Hayasa wo ete orite kite kyûni mukinaoru Baai nado niwa, Syômen kara sitano hô e 90° ni tikai Hôkô kara Kaze wo ukeru koto ni naru ; soreyueni, ue-sitano Hôkô dewa sukunakumo 90° ni tikai Kuiki ga hosii.

Kono Ten kara, watasi wa ue to onazi Riron ni yoru tokorono, Kaze no Hôkô to Hayasa to ryôhô hakareru Kikai wo tukuru koto wo kangaeta. Kore wa *tyokusetuni* korerano Ryô wo simesu Kikai dewa *nai* ga, hituyôna Ryô wo kirokusasete, notini sono Kiroku kara Hôkô to Hayasa wo keisansuru koto no dekiru Kikai de aru.

Hikôki no mae-usirono Diku wo hukunde Hikôki ni taisite kimatta Heimen—Hikôki no tadasii Iti de suiheina Heimen matawa mae-usirono entyokuna Heimen—ni oite Kaze ga kuru mono to suru. Hakarubeki Ryô ga maeno Kakikata no θ to Hayasa V to hutatu aru kara, sukunakumo hutatuno dokurituna Kazu ga kirokusareneba naranai.



Du 8.

Kazeuke-kuda.

Kono Mokuteki ni, watasi wa Du 2 ni aru to onaziyôna Kuda ni Ana wo *san-retu* môkeru koto ni sita. Retu B ga A to C to no tyôdo Mannaka ni atte, $AOB=BOC=\alpha$ to suru (Du 8) ; kono α no tekitôna Atai tositewa 30° wo eranda. Mata, mannakano Retu B no

Hôkô ga Kaze no kuru Hôkô ni taisite tukuru Kaku wo θ to suru.

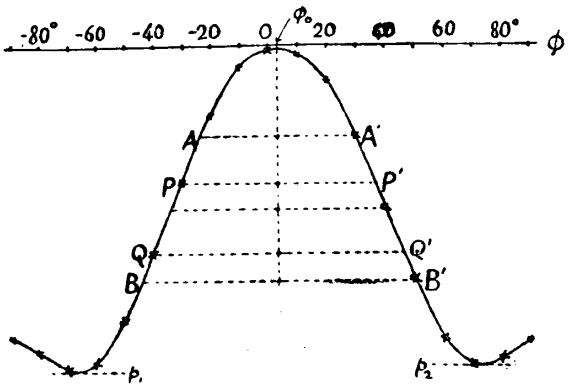
Mae to onaziyôna Hôhô de $p_A - p_B = P_1$ to $p_B - p_C = P_2$ to wo kirokusaseru. Korerano P_1 to P_2 kara ρV^2 (ρ wa Kûki no Mitudo) to θ to wo kimeyô to suru.

Aturyoku to Hôkaku no Kwankei.

Kono Kandyô wo suru niwa, Du 5 no yôna p no φ ni taisuru Kwankei wo narubeku seimituni siru koto ga hituyô de aru. Sorede, maeni tukatta Kuda (Sasiwatasi 0.91 cm.) no hokani sore yorimo sukosi hutoi Kuda (Sasiwatasi 1.27 cm.) de mae to onaziyôna Zikken wo sita.

Kuda ni Mezirusi no Hari wo toritukete sore ga Domori-ita wo sasu yôni si, Kuda no Ana ga oyoso Kaze no kuru Hôkô ni muita to omou Tokoro ni Domori no 0° wo oki, Hari ga Domori-ita de $-90°$, $-80°\ldots-10°$, $0°, +10°\ldots+90°$ wo sasu Tokoro de Kuda no nakano Aturyoku wo mae to onaziyôni yonda. Sore wo Gobanmegami ni utusitoruto, Du 9 no yôna Kyokusen ga erareru (Du 5 no Kyokusen mo kono Hôhô de eta mono de aru).

Domori-ita no $\varphi=0$ wa hontôno $\varphi=0$ dewa nai node, madu hontôno $\varphi=0$ no Iti wo kimeneba naranai. Sore niwa kono Kyokusen no Taisyôsen wo motomereba yoi. Sunawati, p no onazi Atai wo simesu Iti wo migi to hidari de motomete, sore no mannakano Iti wo kimereba yoi. Mottomo, p no tyôdo hitosii Iti ga migi to hidari de tyokusetuni kwansokusarenai no ga tune de aru keredomo, p no Henkwa no kyûna nakahodono Kuiki (Du no AB $A'B'$ no hen) dewa, Kyokusen ga hotondo Tyokusen de aru kara, kono Bubun de p no hitosii Iti wo Du no ue de kimeru koto wa yôini dekiru. Sonoyôni

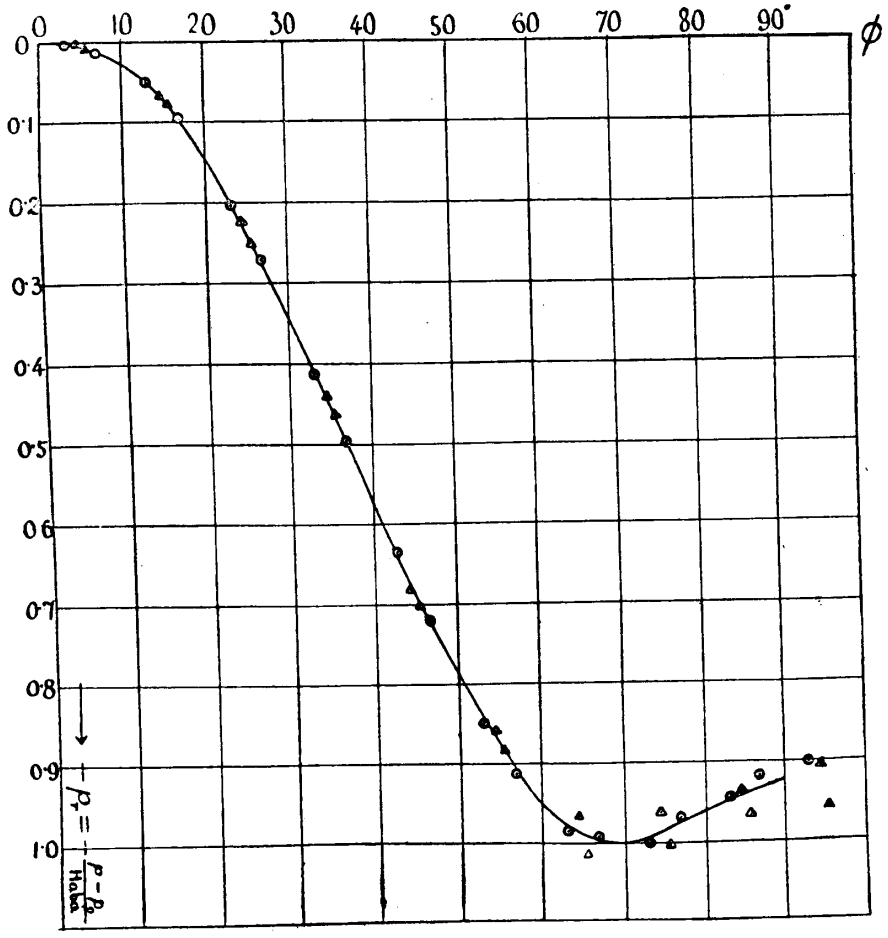


Du 9. × wa sokuteisita Ten.

site AA', PP', QQ', BB' nado no mannakano Ten no φ wo miruto, yoku ittisita Atai φ_0 ga erareru. Kore ga hontôno $\varphi=0$ no Iti de aru.

Tugini, migi to hidarino saisyôno p sunawati Du no p_1 to p_2 (1) to no Heikinsû to $\varphi=\varphi_0$ no p sunawati p_0 to no Sa wo keisansite, sore wo "Aturyoku-henkwa no *Haba*" to suru.

Tugini, $p-p_0$ wo Haba de watta Kazu wo keisansite, sore wo "hikinaosita Aturyoku" to tonaete p_r de simesu. Sosite, Kyokusen no migi mo hidari mo issyoni, hontôno φ sunawati $\varphi-\varphi_0$ ni taisite kono p_r wo morikomu. Sôsuruto, Du 10 de miru yôni, hosoi Kuda mo hutoi



Du 10. ⊙ wa hosoi Kuda, △ wa hutoi Kuda de kwansokusita Ten.

(1) p_1 to p_2 to wa itumo ikuraka tigatte iru ga, kore no Gen'in wa mada Sirabe ga tukanai.

Kuda mo yoku sorotta Kazu wo ataeru ; tada, 60° kara ue de sukosi dutuno Tigai ga aru ga, sorera wo heikinsita Atai wo totte Kyokusen wo hiita no ga kono Kyokusen de aru (1). Tugino Hyô wa onazimono wo Kazu de arawasita mono de aru.

Hyô I. $p_r = \frac{p - p_0}{\text{Haba}}$ on Atai.

φ	p_r	φ	p_r	φ	p_r	φ	p_r
0	·000	±25°	−·239	±50°	− ·784	±75°	−·984
±5°	−·006	±30	− ·342	±55	− ·876	±80	−·962
±10	−·027	±35	−·453	±60	− ·950	±85	−·941
±15	−·072	±40	−·570	±65	− ·990	±90	−.922
±20	−·144	±45	−·681	±70	−1.000		

Kazeuke-kuda ni tuiteno Kandyô.

Kono Hyô ga areba, α no tekigina Atai ni taisite,

$$\frac{P_1}{\text{Haba}} = \frac{p(A) - p(B)}{\text{Haba}} = p_r(A) - p_r(B)$$

$$= p_r(\theta - \alpha) - p_r(\theta)$$

oyobi

$$\frac{P_2}{\text{Haba}} = p_r(\theta) - p_r(\theta + \alpha)$$

no Atai wo Hyô ni tukuri, sore kara Mokuteki no Ryô wo kimeru no ni Tugô no yoi Keisan wo suru koto ga dekiru. Sono Keisan no Zyunzyo wa, tugino Hyô de, ueni soeta Siki wo mireba wakaru.

α no Atai wa, iroirona Ten kara sirabete, 30° to toru no ga Tugô ga yoi node, tugino Hyô wa sonoyôni kimete keisansite aru.

---

(1) φ no ôkii Atai ni taisuru p_r ga ikuraka ayasii kara, narubeku Kaze no Katamuki (θ) no amari ôkiku nai Iti de Kikai wo tukau hô ga yoi.

Hyô II.

θ	(1) $\frac{P_1}{H_a b_a}=\beta_1(\theta-30^\circ)-\beta_1(\theta)$	(2) $\frac{P_2}{H_a b_a}=\beta_1(\theta)-\beta_1(\theta+30^\circ)$	(3) $\frac{P_2-P_1}{H_a b_a}$	(4) $\frac{P_2+P_1}{H_a b_a}$	(5) $\frac{2(P_2-P_1)^2}{(H_a b_a)^2}$	(6) $\frac{\cdot 95(P_2+P_1)^2}{(H_a b_a)^2}$	(7) $\frac{\sqrt{2(P_2-P_1)^2+\cdot 95(P_2+P_1)^2}}{H_a b_a}$	(8) $\frac{P_2+P_1}{P_2-P_1}$	(9) $\frac{P_2-P_1}{P_2+P_1}$	(10) $\cdot 689\frac{P_2+P_1}{P_2-P_1}$	(11) $\tan^{-1}\left(\cdot 689\frac{P_2+P_1}{P_2-P_1}\right)$	(12) $\cdot 414\tan^{-1}\left(\cdot 689\frac{P_2+P_1}{P_2-P_1}\right)$
−60°	+·028	−·028	−·636	+·580	·809	·320	1·052	−·912	−1·097	−·628	−147°·9	−61°·2
−55	−·637	+·055	−·572	−·702	·654	·468	1·059	−1·227	−·815	−·846	−139·8	−57·9
−50	−·640	−·178	−·462	−·818	·427	·636	1·031	−1·771	−·565	1·220	−129·3	−53·5
−45	−·609	−·303	−·306	−·912	·187	·790	·989	2·98	−·336	2·05	−115·9	−48·0
−40	−·543	−·430	−·113	−·973	·026	·899	·962	19·8	−·116	+5·93	−99·6	−41·2
−35	−·447	−·537	+·090	−·984	·016	·920	·967	−10·93	−·160	−7·53	−82·4	−34·1
−30	−·342	−·608	·266	−·950	·142	·857	·999	−3·57	−·280	−2·46	−67·9	−28·1
−25	−·233	−·637	·404	−·870	·326	·719	1·022	−2·15	−·464	−1·484	−56·0	−23·2
−20	−·117	−·640	·523	−·757	·547	·544	1·045	−1·447	−·691	−·997	−44·9	−18·6
−15	·000	−·609	·609	−·609	·742	·352	1·046	−1·000	−1·000	−·689	−34·6	−14·3
−10	+·117	−·543	·660	−·426	·871	·172	1·022	−·646	−1·549	−·445	−24·0	−9·93
−5	·233	−·447	·680	−·214	·925	·044	·984	−·315	−3·18	−·217	−12·2	−5·05
0	·342	−·342	·684	·000	·936	·000	·967	·000	∞	·000	0·0	0·0
5	·447	−·233	·680	+·214	·925	·044	·984	+·315	+3·18	+·217	+12·2	+5·05
10	·543	−·117	·660	·426	·871	·172	1·022	·646	1·549	·445	24·0	9·93
15	·609	·000	·609	·609	·742	·352	1·046	1·000	1·000	·689	34·6	14·3
20	·640	+·117	·523	·757	·547	·544	1·045	1·447	·691	·997	44·9	18·6
25	·637	·233	·404	·870	·326	·719	1·022	2·15	·464	1·484	56·0	23·2
30	·608	·342	·266	·950	·142	·857	·999	3·57	·280	2·46	67·9	28·1
35	·543	·447	−·090	·984	·016	·920	·967	+10·93	+·091	+7·53	82·4	34·1
40	·430	·537	−·113	·973	·026	·899	·962	−8·61	−·116	−5·93	99·6	41·2
45	·303	·609	−·306	·912	·187	·790	·989	−2·98	−·336	−2·05	115·9	48·0
50	·178	·640	−·462	·818	·427	·636	1·031	−1·771	−·565	−1·220	129·3	53·5
55	·055	·637	−·572	·702	·654	·468	1·059	−1·227	−·815	−·846	139·8	57·9
60	−·028	·609	−·636	+·580	·809	·320	1·052	−·912	−1·097	−·628	147·9	+61·2

Aramasino Kwankei hutatu.

Ueno Hyô no (7) no Kudari wo miruto, subeteno Kazu ga mina hotondo 1 ni hitosii. Soreyueni, arappoi Kwankei tosite,

$$\text{Aturyoku-henkwa no Haba}=\sqrt{2(P_2-P_1)^2+\cdot 95(P_2+P_1)^2}$$

to oite yoi. Nao kono Haba wa Kaze no ρV^2 ni hireisuru mono de,

$$\frac{\rho V^2}{\text{Aturyoku-henkwa no Haba}}=k$$

to kakeba, ueno Siki wo

$$\rho V^2=k\sqrt{2(P_2-P_1)^2+\cdot 95(P_2+P_1)^2}$$

to suru koto ga dekiru. k wa 1 ni tikai Kazu de aru.

Mata, ueno Hyô no (12) no Kudari wo miruto, soko no Kazu ga mina θ ni tikai Atai ni natte iru. Soreyueni, ôyosono Kwankei tosite,

$$\theta=\cdot 414\tan^{-1}\left(\cdot 689\frac{P_2+P_1}{P_2-P_1}\right)$$

kono Siki wo mitomeru koto ga dekiru. Koko ni aru Kazu ·689 wa $\sqrt{\frac{\cdot 95}{2}}$ no Atai; ·414 wa $P_2-P_1=0$ ni taisuru θ no Atai 37°·3 wo 90° de watta Hi de aru (1).

Nao, seimituna Kwankei wo

$$\cdot 414\tan^{-1}\left(\cdot 689\frac{P_2+P_1}{P_2-P_1}\right)=\theta+\Delta$$

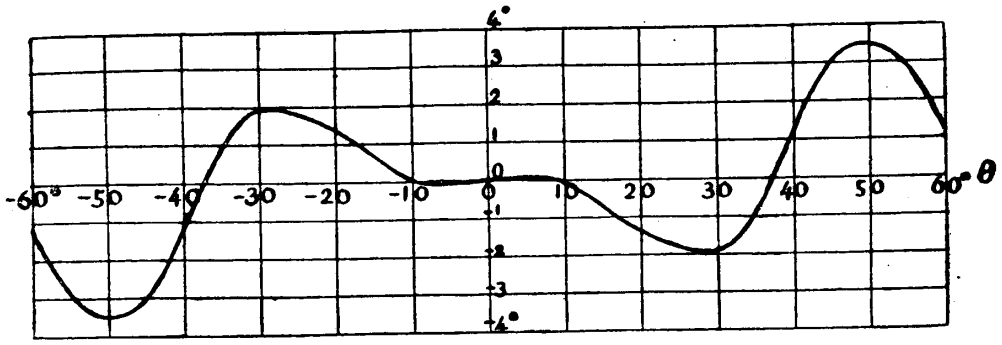
to okeba, Δ wa θ ni taisite Du 11 no Kyokusen no yôni naru.

Ueno ôyosono Kwankei wa

$$A(P_2-P_1)^2+B(P_2+P_1)^2 \text{ ga } \theta \text{ ni mukwankei;}$$

$$\frac{P_2+P_1}{P_2-P_1}=\gamma\tan\lambda\theta,$$

(1) $a\tan^{-1}\left(b\frac{P_2+P_1}{P_2-P_1}\right)$ no Katati de a to b wo ueno Kazu to mukwankeina tekitôna Kazu (tatoeba $a=\cdot 408$, $b=\cdot 78$) ni toreba, θ ni taisuru saidaino Sa wo 1·5° ika ni suru koto mo dekiru. Sikasi, kono Siki wa Keisan no tameni tukau Hituyô ga nai kara, kuwasikuwa nobenai.



Du 11.

kôiu Katati ni natte iru ga, kore wa gûzenno Kwankei dewa nakute, yôsuruni φ ni taisuru p no Kwankei (Du 5) ga hobo Seigen-kyokusen no Katati ni natte iru koto no Kekkwa de aru.

Ima, $p(\varphi)$ ga mattaku Seigen-kyokusen de aru to sureba,

$$p(\varphi)=p_0-C\sin^2 h\varphi$$

to okeru. Tadasi C wa Aturyoku-henkwa no Haba.

Sô suruto,

$$P_1=p(\theta-\alpha)-p(\theta)=C\{\sin^2 h\theta-\sin^2 h(\theta-\alpha)\}$$

$$=\frac{1}{2}C\{\cos 2h(\theta-\alpha)-\cos 2h\theta\}=C\sin h\alpha\sin h(2\theta-\alpha),$$

$$P_2=p(\theta)-p(\theta+\alpha)=C\sin h\alpha\sin h(2\theta+\alpha).$$

Sitagatte,

$$P_2+P_1=2C\sin h\alpha\cos h\alpha\sin 2h\theta,$$

$$P_2-P_1=2C\sin^2 h\alpha\cos 2h\theta\ ;$$

yueni,

$$\sqrt{\frac{1}{4\sin^4 h\alpha}(P_2-P_1)^2+\frac{1}{\sin^2 2h\alpha}(P_2+P_1)^2}=C.$$

Mata,

$$\frac{P_2+P_1}{P_2-P_1}=\cot h\alpha\tan 2h\theta.$$

Kore ga wareware no mita Katati de aru.

Mottomo, zissaino Kyokusen wa tadasii Seigen-kyokusen de nai kara, zissaino Kazu ni tugôyoku totta Keisû $A=2$, $B=\cdot 95$ wa kono Siki no $1/(4\sin^4 h\alpha)$ to $1/\sin^2 2h\alpha$ ni seimituni au wake dewa nai.

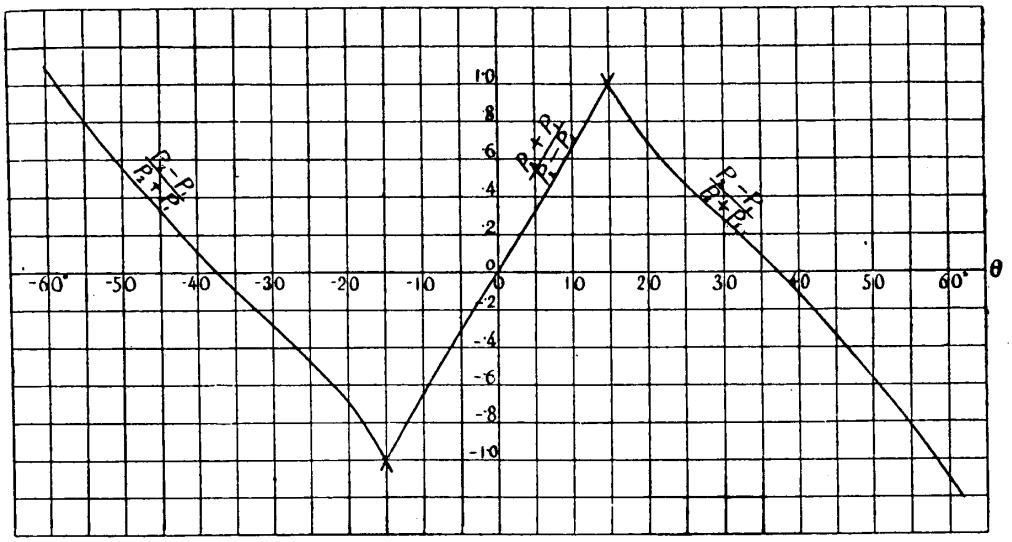
P_1 P_2 kara ρV^2 to θ no Keisan.

Kirokusareta Kazu P_1, P_2 kara θ wo zissaini keisansuru niwa, Hyô II no (8) to (9) no Kudari no Kazu wo gyakuni totta tugino Hyô wo tukau hô ga kantan demo ari mata seimitu demo aru :—

Hyô III.

$-1 \leqq \frac{P_2+P_1}{P_2-P_1} \leqq 1$, katu $P_2-P_1>0$ no Baai		Hokano Baai		
		$\frac{P_2-P_1}{P_2+P_1}$	θ	
$\frac{P_2+P_1}{P_2-P_1}$	θ		$P_2+P_1<0$	$P_2+P_1>0$
		$-1\cdot1$	—	$+60°\cdot1$
$-1\cdot0$	$-15°\cdot0$	$-1\cdot0$	$-15°\cdot0$	58·4
$-\ \cdot9$	$-13\cdot6$	$-\ \cdot9$	$-16\cdot4$	56·6
$-\ \cdot8$	$-12\cdot2$	$-\ \cdot8$	$-18\cdot0$	54·7
$-\ \cdot7$	$-10\cdot8$	$-\ \cdot7$	-19.8	52·8
$-\ \cdot6$	$-\ 9\cdot4$	$-\ \cdot6$	-21.8	50·8
$-\ \cdot5$	$-\ 7\cdot9$	$-\ \cdot5$	$-24\cdot1$	48·7
$-\ \cdot4$	$-\ 6.4$	$-\ \cdot4$	$-26\cdot7$	46·5
$-\ \cdot3$	$-\ 4\cdot8$	$-\ \cdot3$	-29.4	44·3
$-\ \cdot2$	$-\ 3\cdot2$	$-\ \cdot2$	-32.3	42·0
$-\ \cdot1$	$-\ 1.6$	$-\ \cdot1$	-34.8	39·7
·0	0·0	0	$-37\cdot3$	37·3
$+\ \cdot1$	$+\ 1.6$	$+\ \cdot1$	$-39\cdot7$	34·8
·2	3.2	·2	-42.0	32·3
·3	4.8	·3	$-44\cdot3$	29·4
·4	6·4	.4	$-46\cdot5$	26·7
·5	7.9	·5	$-48\cdot7$	24·1
·6	9.4	·6	-50.8	21·8
·7	10.8	·7	$-52\cdot8$	19·8
·8	12.2	·8	$-54\cdot7$	18·0
·9	13.6	·9	$-56\cdot6$	16·4
$+1\cdot0$	$+15\cdot0$	1·0	$-58\cdot4$	15·0
—	—	$+\ 1\cdot1$	$-60\cdot1$	—

Du 12 wa kono Kwankei wo arawasita mono de aru.

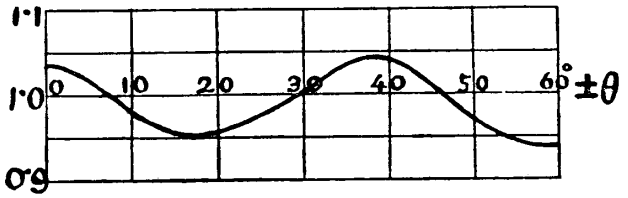


Du 12.

Mata ρV^2 wa, maeno ôkina Hyô no (7) no Kudari no Kazu no Gyakusû wo $F(\theta)$ to site,

$$\rho V^2 = k\sqrt{2(P_2-P_1)^2+\cdot 95(P_2+P_1)^2}\times F(\theta)$$

de keisansureba yoi. $F(\theta)$ no Atai wa tugino Hyô oyobi Du 13 no tôri :—



Du 13.

Hyô IV.

θ	$F(\theta)$	θ	$F(\theta)$	θ	$F(\theta)$
0	1·034	±25°	·978	±50°	·970
± 5°	1·016	±30	1·001	±55	·944
±10	·979	±35	1·034	±60	·941
±15	·956	±40	1·040		
±20	·957	±45	1·011		

k no tasikana Atai wa, kono Kenkyû ni tukatta tiisai Hûtô dewa erarenai; 1 yorimo ôkiku deta koto mo tiisaku deta koto mo aru node, koko dewa tada 1 ni tikai Kazu da to iu koto dake ga ieru.

Konoyôni site P_1 to P_2 no Kwansoku kara ρV^2 to θ to wo kimeru koto ga dekiru no de aru.

Kikai no tukaeru Kuiki ga migi hidari awasete 120° mo aru kara, maeni nobeta uesitano Heimen ni okeru Tukaimiti niwa zyûbun Yoyû ga aru. Kono Baai niwa $\theta=0$ no Hôkô wo Syômen ni mukenaide, Syômen kara 40° gurai sitani muketa Hôkô ni toru hô ga yoi.

Dukei wo tukau Hôhô.

P_1 to P_2 to wo sokuteisita tokini, Sûzi no Keisan wo sezuni, hitotuno Dukei wo mite suguni ρV^2 to θ to wo siru koto ga dekiru.

Sore niwa, madu ueno aramasino Kwankei

$$\rho V^2 = C\sqrt{2(P_2-P_1)^2+\cdot 95(P_2+P_1)^2}$$

$$=\sqrt{2}\,C\sqrt{(P_2-P_1)^2+\cdot 689^2(P_2+P_1)^2},$$

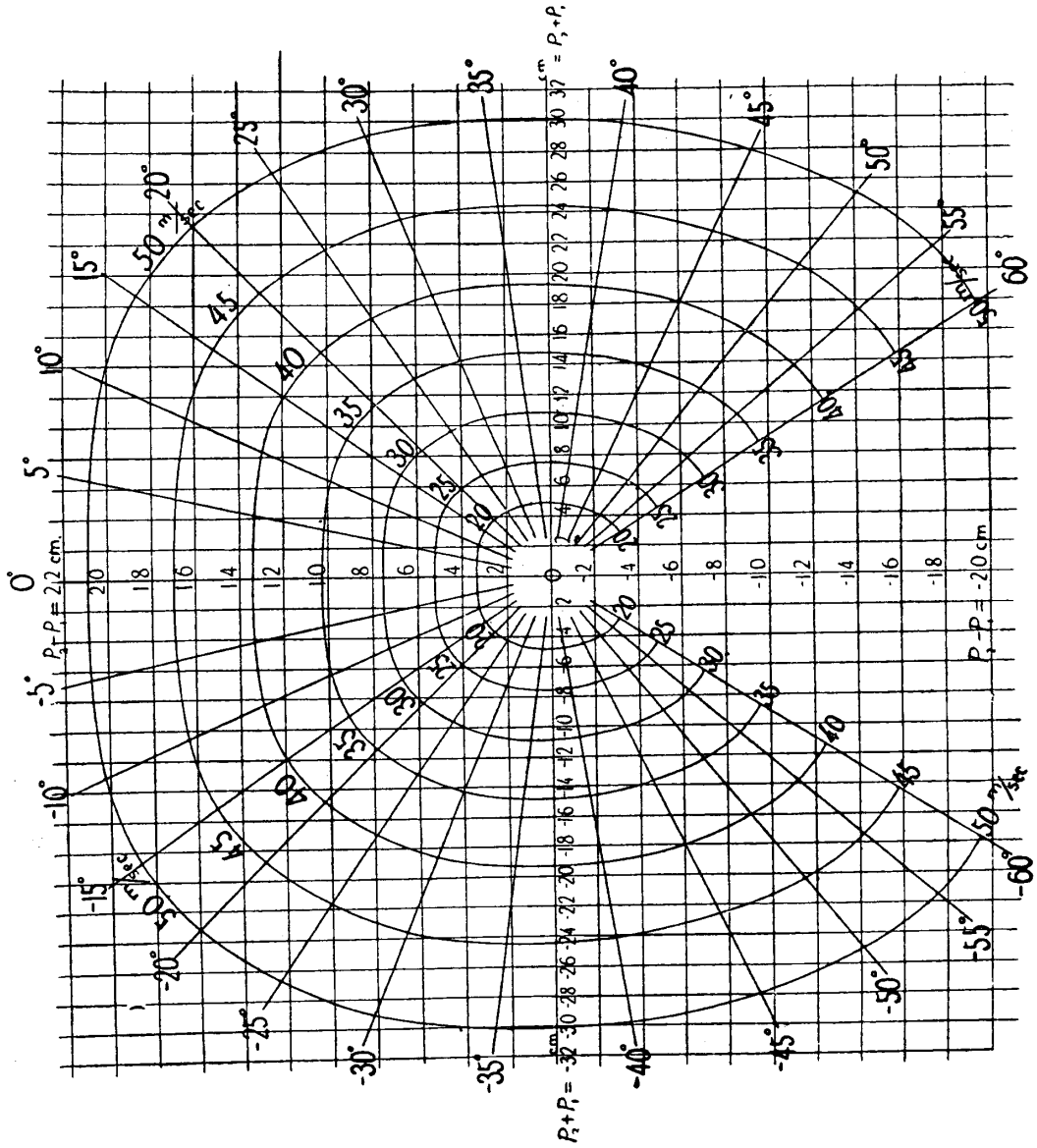
$$\theta=\cdot 414\tan^{-1}\frac{\cdot 689(P_2+P_1)}{(P_2-P_1)}$$

wo kangaeru. Ima

$$x=P_2-P_1,\quad y=\cdot 689(P_2+P_1)$$

no Tyokkaku-zahyô wo motu Ten wo kangaeruto, sore no Kyokuzahyô r wa ρV^2 ni hireisi, Dôkei no x-Diku ni taisuru Kaku wa θ ni hireisuru. Soreyueni, karini ρ wo kimatta mono to minasu naraba, Du 14 no yôna Dukei wo tukutte, θ to V to wo Hazime kara kakikonde oku koto ga dekiru. Mata, y no ·689 no Kakezan mo itiiti suru niwa oyobanai; $x=$ const. $y=$const. no Sen wo hiite, P_2-P_1 to P_2+P_1 no Atai wo Hazime kara kakikonde okeba, ataerareta. P_2-P_1 to P_2+P_1 to no Kiriaiten no θ to V to ga suguni yomeru.

Ueno hutatuno Kwankei ga seimituna mono de nai koto mo, kono Hôhô wo tukau no ni zyamani naranai. $\theta=$const. no Sen wa hitosii Kankaku de naku, P. 13 no Hyô no (11) no Kudari ni sitagatte hiite okeba



Du 14.

yoi. Mata ρV^2 (matawa V) no hô no Naosi wa, En wo mattakuno En de naku, onazi Hyô no (7) no Kudari ni sitagatte, r no Atai wo, Hôkô ni yotte sukosi dutu kagensite hiite okeba, itu demo tadasii ρV^2 matawa (ρ ga kimatte oreba) V no Atai wo yomitoru koto ga dekiru.

Du 14 dewa, P_2+P_1 oyobi P_2-P_1 wa Midu-basira no Takasa (cm.) de arawasite aru. Mata, Kyokusen ni soeta Kazu wa, $\rho=1{\cdot}2$ mai-

rippômêtoru-kiroguramu, $k=1$ to totte keisansita Hayasa (maibyô-mêtoru) de aru.

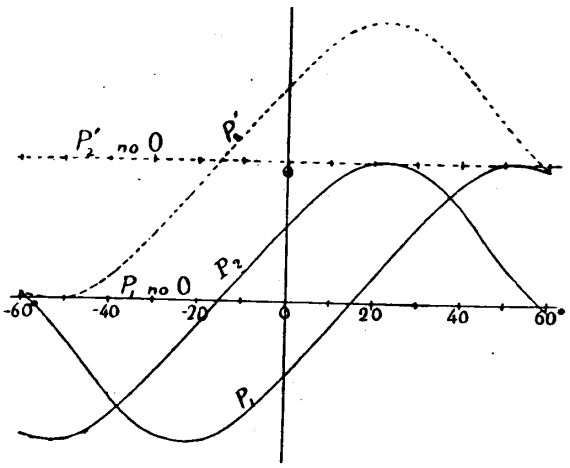
Zissai niwa P_2-P_1 to P_2+P_1 no Sen wo akaku, V to θ no Sen wo kuroku kaku yôna koto ni suru ga benri de arô.

Aramasino Sekkei.

Ueni nobeta Riron ni yotte P_1 to P_2 wo kirokusuru Kikai wa mada dekiagatte inai(1). Ima sugu sore no Seizô ni kakaru koto ga dekinai tameni, kokoni ueno Riron to ôyosono Sekkei dake wo nobete oku.

Kono Kikai no ôyosono Sikake wa hutûno Ziki-seiukei to dôyô de aru. Namigata-bako wo yattu gurai kasaneta mono wo hutakumi torituke, sore no Naka wo hitokumi gotoni mina renrakusite, katu Kuda de soto to renraku dekiru yôni suru. Mata Sotobako wo Kûki no morenai yôni site, sore ni renrakusuru Kuda wo tukete oku koto wa Yokosuberi-bakari de sita tôrini suru.

d_1 d_2 hutatu no Kiroku wa, *onazi* Kami ni toru koto ga Tugô ga yoi.



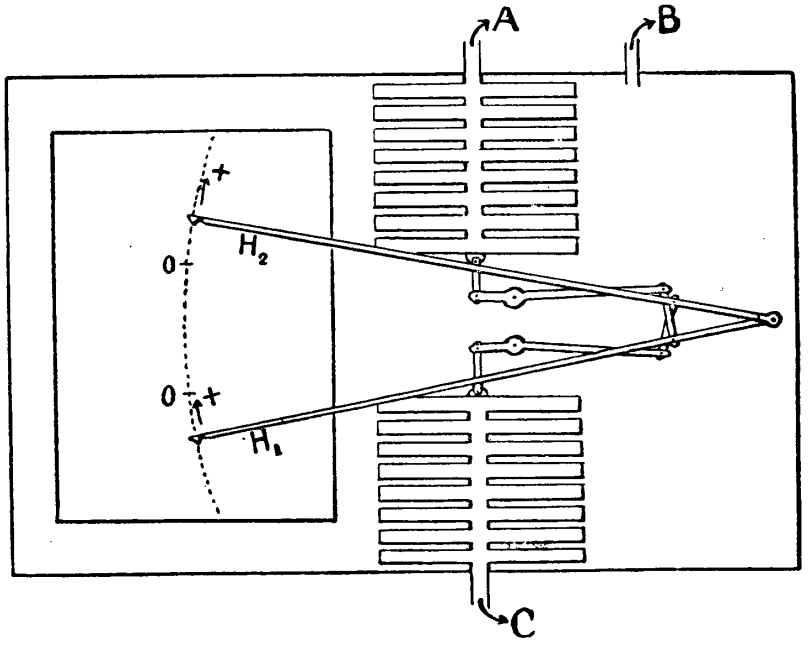
Du 15.

Sore niwa, hutakumino Namigata-bako no Nobi-tidimi wo kakudaisite simesu Hari nihon no Kwaitendiku wo onazi Tyokusen—Ziki-seiukei no Tokei ni maita Kami ni aru tateno Kosen no Tyûsin ni ataru Tyokusen —no ueni aru yôni suru. Tadasi, hutatu no Reiten wa, Hari ga katiawanai tameni hanasite oku Hituyô ga aru. P_2 wo + no Gawa ni zurasu mono to site, mosimo migi-

(1) Ugokanai Basyo tatoeba Hûtô no nakano Kaze wo siraberu nado no Mokuteki niwa, Ekitai no Aturyokukei de P_1 to P_2 wo sokutei dekiru.

hidari awasete 120° no Kuiki ni tukau naraba,—Du 15 de P_1 P_2 oyobi P_2 wo zurasita P_2' no Kyokusen wo mireba sireru tôri—hutatuno Reiten no Hedatari wo Hari no ugoki uru Haba (Kiroku no Kami no Haba) no *sanbunno iti* ni toreba yoi. Mosimo Kuiki ga migi-hidari awasete 70° de yoi naraba, ôku Reiten wo zurasu Hituyô ga nai ; tada Seisi no Iti de hutatuno Hari ga sawaranai dakeno sukosino Hedatari ni site yoi.

Konoyôni P_1 no Hari no ugoku Kuiki to P_2 no Hari no ugoku Kuiki to ga itibubun kasanariatte sikamo hutatu ga katiawanai tameniwa, P_1 to P_2 to no + no Muki ga onazi Muki ni natte oru koto ga hituyô de aru. Kore wa, hutakumino Namigatabako wo, Du 16 no yôni, Sotobako no



Du 16.

mukiatta Gawa ni tagaini mukiawasete toritukete okeba yoi. Ueno Namigatabako wo Kazeukekuda no A no Ana ni, sitano Namigatabako wo C no Ana ni tunageba, $P_1=p_A-p_B$ no masu tokinimo, $P_2=p_B-p_C$ no masu tokinimo, Hari H_1 H_2 no Saki ga *ueni* ugoku.

Kono Kikai no Hari no Ugokikata wa θ ni kwankeisuru hoka, V^2 ni hireisuru kara, Hikôki no Sakaotosi no Baai no yôni Sokudo no toku-

betuni ôkii Undô wo kirokusi uru yôni tukureba, hutûno Hayasa dewa Hari no ugoku Kuiki ga semaku natte, tatoeba maeno Yokosuberi-bakari no yôni, matawa hutûno Iti de Tubasa ni Kaze no ataru Muki wo miru nado no Mokuteki ni 1° ya 2° no Katamuki wo miru niwa hutekitôni naru. Soreyueni, hutûno Hayasa no Zikken ni tukau no to ôkina Hayasa ni tukau no to, Kanzi no tigau Kikai wo betuni tukuru koto ga hituyô de aru.

Kattena Hôkô no Kaze wo kirokusuru koto.

Koremade nobeta no wa, Kaze no Muki ga Kazeuke-kuda ni suityokuna Heimen ni aru to kimete itta no de aru. Kaze ga Kazeuke-kuda ni suityoku de nakute, sore ni heikôna Seibun wo motte iru Baai ni Kûki no Kuda ni *suityokuna Undô ga sore ni heikôna itiyôna Undô no kasanaru koto ni yotte Eikyô wo ukenai* to kateisureba, kono Kikai ga, mae to onaziyôni, Kuda ni *suityokuna Sokudo-seibun no Hôkô oyobi Ooisa wo simesu* koto ni naru. Nazekanareba, Kuda no ueno iroirona Ten ni oite,

q wo nanamena Sokudo,
u wo Kuda ni heikôna Seibun,
v wo Kuda ni suityokuna Heimen ni okeru Seibun

to suruto, Aturyoku wa

$$p=C-\frac{1}{2}\rho q^2=C-\frac{1}{2}\rho(u^2+v^2);$$

sitagatte,

$$P_1=p_A-p_B=\frac{1}{2}\rho(u_B^2+v_B^2-u_A^2-v_A^2).$$

Sikaruni, $u_B=u_A$ de aru kara,

$$P_1=\frac{1}{2}\rho(v_B^2-v_A^2).$$

P_2 ni tuiteno dôyô de, subeteno Koto ga u ga nai Baai to onazikoto ni naru.

Kokoni nobeta Katei sunawati v no Bunpu ga u kara Eikyô wo ukenai to iu Wake wa, u ga zissai nai Baai ni Kuda zisin wo sore no Nagasa no Hôkô ni ugokasu to kangaete miru ni v ga kono Undô no tameni Eikyô wo ukeru wake ga nai to iu koto kara osite kangaerareru.

Kaze ga Hikôki ni taisite kattena Hôkô kara kuru tokini sore no Hôkô oyobi Hayasa wo siru koto wa, sore wo mae-usiro, yoko, tate mittuno Hôkô ni bunkaisita Seibun wo siru koto to onazi de aru. Ima, ueni nobeta yôna Kikai wo *hutatu* totte, hitotu no Kazeuke-kuda wo yokoni, mohitotu no wo tateni sôtisite okeba, yokono Kuda kara mae karano Sokudo to ue-sitano Sokudo, tateno Kuda kara yokono Sokudo to mae karano Sokudo ga sireru. Mae karano Sokudo ga hutatu aru koto wa Sokutei no Tasikasa no Meyasu wo ataeru.

Kaze no Hôkô to Hayasa wo tyokusetuni simesu Kikai.

Kokoni nobeta Kikai wa P_1 to P_2 wo kirokusite, ato kara Kaze no Hôkô to Hayasa wo Keisan de dasu to iu Kikai de aru ga, sô de nakute, sonotoki-sonotoki no Hôkô to Hayasa wo tyokusetuni yomitoru koto no dekiru Kikai mo kangaerareru.

Sore wa, Du 14 no Dukei to dôyôna Kangae de dekiru. Sunawati, tekitôna Sikake ni yotte, Mezirusi no Ten ga, Kikai ni koteisita Ita no ueni,

$$x=P_2-P_1, \qquad y=\cdot 689(P_2+P_1)$$

wo Zahyô ni suru Iti ni arawareru yôni suru koto ga dekireba yoi no de aru. Ita no ueni, Du 14 no yôna Kyokusen to Dôkei—tate-yoko no Sen wa iranai—wo hiite, θ to V no Kazu wo kakikonde okeba, suguni θ to V to wo yomitoru koto ga dekiru.

Mezirusi no Ten ga $x=P_2-P_1$, $y=\cdot 689(P_2+P_1)$ ni sitagatte ugoku yôni suru Sikake ni tuitewa ikurakano Kangae ga aru keredomo, mada gutaitekina Sekkei madeniwa susunde inai.
