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AF

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ATTENDE BIND

KRISTIANIA

ALB. CAMMERMEYERS FORLAG

LARS SWANSTRØM

1896

OM

DIRECTIONENS ANALYTISKE BETEGNING,

ET FORSØG,

ANVENDT FORNEMMELIG

TIL

PLANE OG SPHÆRISKE POLYGONERS OPLØSNING

AF

CASPAR WESSEL, LANDMAALER.

Med en Fortale af Sophus Lie.

KRISTIANIA
ALB. CAMMERMEYERS FORLAG
(LARS SWANSTRØM)

CENTRALTRYKKRRIET — KRISTIANIA 1896

Fortale.

Norske Mathematikere har indtil den sidste Tid staaet i den Formening, at den høiere Mathematik i Norge begyndte med *Niels Henrik Abel*. Hans udødelige Undersøgelser aabnede, som alle ved, nye udstrakte Felter, hvis Bearbeidelse gjennem Decennier har lagt Beslag paa Aarhundredets første mathematiske Kræfter.

Nu viser det sig imidlertid, høist mærkelig, at der før *Abel* har været en norsk Mathematiker, der et fjerdedels Aarhundrede tidligere fremsatte grundlæggende Ideer, som utvivlsomt vilde være blevet banebrydende, om de ikke vare blevne upaaagtede.

I 1796 indleverede Nordmanden *Caspar Wessel*, en Broder af Digteren Johan Herman Wessel, til det danske Videnskabernes Selskab denne Afhandling[1]) som indeholder en klar og fuldstændig Fremstilling af den geometriske Imaginærrepræsentation, som først senere antydedes, om end kun implicite af den store *Gauss*, hvis høit berømte Doktorafhandling (1799) dog kun for en ringe Del dækker sig med Caspar Wessels Arbeide. Fuldstændigere indførtes Theorien af Franskmændene *Argand* (1806) og *Mourey* (1820) af Englænderen *Warren* (1821) samt af Italieneren *Bellavitis*. Disse Mathematikere synes, da ingen nævner sine Forgjængere, at have arbeidet uafhængig af hverandre og af *Caspar Wessel*. I *Cauchy's* og *Riemanns* Hænder er disse Ideer blevet det formelle Grundlag for vort Aarhundredes Funktionstheori, blandt hvis Grundlæggere *Abel* indtager den første Plads ved Siden af *Cauchy*.

Caspar Wessels Arbeide indeholder imidlertid foruden Imaginærtheorierne mærkelige Betragtninger, som den danske Mathe-

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[1]) Afhandlingen foreligger trykt i Ny Samling af det Kongelige Danske Videnskabernes Selskabs Skrifter, Kjøbenhavn 1799.

matiker *Juel*[2]) med rette betegner som Forløber til Englænderen *Hamiltons* berømte Quaternioncalcul.

Hvis *Caspar Wessels* Arbeide var kommet til sin Ret, saa vilde han forlængst have vundet et fuldt saa stort Navn i Mathematikens Rige som hans Broder Johan Herman Wessel inden den nordiske Litteratur og som hans Onkel *Petter Wessel (Tordenskjold)* vandt som Kriger.

Caspar Wessel er, saavidt vides, ikke tidligere blevet omtalt af nogen, det være norsk, dansk eller fremmed Mathematiker, førend Overlærer *Christensen* i Odense i sin Doktorafhandling (1894) gav et sandsynligvis meget fuldstændigt Referat af danske og norske mathematiske Arbeider i forrige Aarhundrede og ved denne Anledning ogsaa omtalte Caspar Wessels Arbeide. Herved blev den danske Mathematiker *Juels* Opmærksomhed først henledet paa samme og han erkjendte dets Værd.

Det er nu Norges Sag at gjøre, hvad der bør gjøres for at denne mærkelige Mands Minde kan fremdrages af Glemselen og hans Navn finde sin rette Plads inden Mathematikens Historie. Foreløbig reproducere vi her *Caspar Wessels* originale Afhandling i Archivet.

Kristiania, 15de September 1895.

Sophus Lie.

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[2]) Dansk mathematisk Tidsskrift 1895.

Om Directionens analytiske Betegning, et Forsøg, anvendt fornemmelig til plane og sphæriske Polygoners Opløsning.

Af

Caspar Wessel, Landmaaler.

Nærværende Forsøg angaaer det Spørgsmaal, hvordan Directionen analytisk bør betegnes, eller hvordan rette Linier burde udtrykkes, naar af een eneste Ligning mellem een ubekiendt og andre givne Linier skulde kunne findes et Udtryk, der forestillede baade den ubekiendtes Længde og dens Direction.

For nogenledes at kunne besvare dette Spørgsmaal, lægger jeg til Grundvold to Sætninger, der synes mig unegtelige. Den første er: at den Directionens Forandring, der ved algebraiske Operationer kan frembringes, ogsaa bør ved deres Tegn at forestilles. Den anden: at Direction er ingen Gienstand for Algebra, uden for saavidt den ved algebraiske Operationer kan forandres. Men da den ved disse ei kan forandres (i det mindste efter den sædvanlige Forklaring), uden til den modsatte, eller fra positiv til privativ, og omvendt: saa skulde disse to Directioner alene kunne betegnes paa den bekiendte Maade, og i Hensigt til de ovrige Problemet være uoploseligt. Dette er vel ogsaa Grunden, hvorfor ingen dermed har befattet sig.[1]) Man har uden Tvivl holdt det for utilladeligt at forandre noget i Operationernes eengang antagne Forklaring. Og derimod er intet at indvende, saalænge Forklaringen anvendes paa Størrelser i Almindelighed; men i enkelte Tilfælde, naar Størrelsernes egen Natur synes at indbyde til Operationernes nøiere Bestemmelse, og denne med Nytte kan anvendes, bør samme vel ei kaldes utilladelig; thi gaaer man fra Arithmetiken over til den geometriske Analysis, eller fra Operationer med abstracte Tal til dem med rette Linier, faaer man Størrelser at betragte, der vel kan tage imod samme, men ogsaa imod langt flere Relationer, end de, som Tallene kan have til hinanden; om man derfor nu tager Operationerne i en vidtløftigere Mening, og ei, som før, blot indskrænker dem til den Brug, at kunne foretages med Linier af samme eller modsat Retning, men udstrækker nu deres forrige indskrænkede Begreb noget videre, saa at det bliver anvendeligt, ei alene i samme Fald, som før, men ogsaa i uendelig mange flere Tilfælde; jeg siger om man tager sig denne Frihed, og dog ei derved overtræder de sædvanlige Operationsregler, saa modsiger man jo ikke derfor den første Lære om Tallene; men man udfører den kun videre, lemper sig efter Størrelsernes Natur, og iagttager den Methodes Regel, der fordrer, lidt efter lidt at gjøre en vanskelig Lære fattelig. Det bliver altsaa ingen urimelig Fordring, at Operationerne anvendte i Geometrien tages i en vidtløftigere Mening, end den man i Regnekunsten gav dem; man vil ogsaa let tilstaae, at det paa den Maade maa være muelig at frembringe uendelig mange Forandringer i Liniernes Retning. Men just derved opnaaes (som siden

[1]) Uden det skulde være Magister Gilbert i Halle, hvis Priisskrivt over *Calculus Situs* maaskee indeholder en Forklaring over dette Æmne.

skal bevises) ei alene, at alle umuelige Operationer kan undflyes, og den paradoxe Sætning, at det Muelige maa undertiden søges ved umuelige Midler, kan oplyses, men ogsaa at Directionen af alle Linier i samme Plan kan udtrykkes ligesaa analytisk, som deres Længde, uden at Hukommelsen bebyrdes med nye Tegn eller Regler. Og da det synes upaatvivleligt, at geometriske Sætningers almindelige Rigtighed ofte bliver lettere at indsee, naar Directionen analytisk kan betegnes, og underkastes de algebraiske Operationsregler, end naar den ved Figurer, og kun i enkelte Tilfælde, skal forestilles: saa synes det ogsaa ei alene tilladeligt, men endog gavnligt, at betjene sig af Operationer, der udstrækkes til flere Linier, end de ligestilte (de af samme Retning) og de modsatte. Paa Grund heraf søger jeg

I. Først at bestemme Reglerne for saadanne Operationer;
II. Dernæst vises ved et Par Exempler deres Anvendelse, naar Linierne er i samme Plan;
III. Derefter bestemmes Directionen af Linier i forskjellige Planer ved en ny Operationsmethode, der ikke er algebraisk;
IV. Ved Hielp af denne udfindes derpaa saavel plane som sphæriske Polygoners Opløsning i Almindelighed;
V. Tilsidst udledes paa samme Maade de i den sphæriske Trigonometrie bekiendte Formler.

Dette er Hovedindholdet af denne Afhandling. Anledningen dertil var, at jeg søgte en Methode, hvorved de umuelige Operationer kunde undgaaes, og da denne var funden, anvendte jeg samme, for at overbevises om nogle bekiendte Formlers Almindelighed. Disse første Undersøgelser havde Hr. Etatsraad Tetens den Taalmodighed at gjennemlæse, og denne navnkundige Lærdes Opmuntringer, Raad og

Veiledning skylder jeg, saavel at dette Skrivt nu fremkommer mindre ufuldkomment, som og at det er værdiget, at optages i Samlingen af det Kongelige Videnskabers Selskabs Skrivter.

I.

Paa hvad Maade af givne rette Linier ved de algebraiske Operationer formeres andre, og fornemmelig hvad Retning og Tegn disse skal have.

Der gives homogene Størrelser, hvilke, naar de faae Sted hos samme Subject, foroge eller formindske hinanden paa den Maade alene, som Incrementer og Decrementer.

Der gives andre, som i samme Tilfælde kunne forandre hinanden paa utallige flere Maader. Af dette sidste Slags ere rette Linier.

Saaledes kan et Puncts Afstand fra et Plan paa utallige Maader forandres derved, at Punktet beskriver udenfor Planet en meer eller mindre inclineret ret Linie.

Er nemlig denne Linie perpendicular, det er, giør Punctets Vei en ret Vinkel med Planets Axel, saa bliver Punctet i Planets Parallel, og dets Vei har ingen Virkning paa dets Afstand fra Planet.

Er den beskrevne Linie indirect, det er, giør den en skiev Vinkel med Planets Axel, saa bidrager den et mindre Stykke end sin egen Længde til Afstandens Forlængning eller Forkortning, og kan paa uendelig mange Maader forøge eller formindske Afstanden.

Er den direct, det er i Linie med Afstanden, tillægger eller fratager den samme sin hele Længde, og er i første Fald positiv, i andet privativ.

Alle de rette Linier, som af et Punct kan beskrives, ere altsaa, i Hensigt til deres Virkning paa Punctets givne Afstand fra et udenfor Linierne opstilt Plan, enten directe eller indirecte, eller perpendiculare,[1]) alt eftersom de tillægge eller fratage Afstanden saa meget som det Hele, eller en Deel eller intet af deres egen Længde.

Da en Størrelse kaldes absolut, for saavidt den ei ved Relation til en anden, men umiddelbar antages given, saa kan i foregaaende Definitioner Afstanden kaldes den absolute Linie, og den relatives Bidrag til den absolutes Forlængning eller Forkortning kan kaldes den relatives Virkning.

Der gives endnu flere Størrelser end rette Linier, der kunne tage imod omtalte Relationer. Det var derfor ikke unyttigt, at forklare disse Relationer i Almindelighed, og at indlemme deres almindelige Begreb i Operationernes Forklaring; men da baade Kienderes Raad, dette Skrivts Indhold, og Foredragets Tydelighed fordre, ei at besvære Læseren med saa abstracte Begreb, befatter jeg mig kun med de geometriske Forklaringer alene, og siger derfor, at

§ 1.

To rette Linier adderes, naar man først føier dem sammen, saaledes at den ene begynder, hvor den anden slipper, derefter drager fra de sammenføiedes første til sidste Punct en ret Linie og antager saa denne for de sammenføiedes Sum

Gaaer f. Ex. et Punct 3 Fod frem, og derefter 2 Fod tilbage, saa er disse to Veies Sum ikke de første 3 og sidste 2 Fod sammenføiede; men een Fod frem er Summen, for saavidt denne Vei, af samme Punct beskreven, har samme Virkning, som begge de to andre Veie.

[1]) Indifferente var mere passende, om det ikke skurrede for meget i uvante Øren.

Ligeledes naar en Triangels ene Side strækker sig fra a til b, og den anden fra b til c, maa den tredie fra a til c kaldes Summen, og maa betegnes ved ab + bc, saa at ac og ab + bc have samme Betydning, eller ac = ab + bc = — ba + bc, dersom ba er det modsatte af ab. Ere de adderte Linier directe, stemmer Definitionen fuldkommen overens med den sædvanlige. Ere de ikke directe, strider det dog ikke mod Analogien, at kalde en ret Linie to andre sammenføiedes Sum, for saavidt den har samme Virkninger, som disse. Den Betydning jeg har givet Tegnet +, er heller ikke saa usædvanlig; f. Ex i den Expression,

$$ab + \frac{ba}{2} = \tfrac{1}{2}ab$$

er $\frac{ba}{2}$ ingen Deel af Summen. Man kan derfor ogsaa sætte ab + bc = ac, uden derfor at tænke sig bc som nogen Deel af ac; ab + bc er kun det Tegn, hvorved ac forestilles.

§ 2

Naar flere end to rette Linier skal adderes, følges samme Regel; de forenes nemlig, saa at førstes sidste Punct sammenføies med det første af den anden, dennes sidste med tredies første o. s. v., derefter drages fra det Punct, hvor første begynder, til det, hvor sidste slipper, en ret Linie, og denne kaldes Summen af dem alle.

Hvad for en Linie der skal tages for den første, og hvilken for den anden, tredie o. s. v., er ligegyldigt; thi paa hvad Sted indenfor tre Planer, der gjør rette Vinkler med hinanden, en ret Linie af et Punct beskrives, har denne Linie samme Virkning paa Punctets Afstand fra hver af Planerne; følgelig bidrager een af flere adderte Linier til Positionens Bestemmelse af Summens sidste Punct ligesaa meget, naar den er den første, som naar den er den sidste, eller hvad anden Orden den har til de andre adderte; følgelig er Ordenen i rette Liniers Addition ligegyldig, og Summen bliver alletider den samme, fordi dens første Punct antages given, og det sidste faar alletider samme Position.

Derfor kan ogsaa i dette Tilfælde Summen betegnes ved de adderte Linier forbundne med hinanden ved Tegnet +. Naar i en Fiirkant f. Ex. den første Side er dragen fra a til b, den anden fra b til c, den tredie fra c til d men den fierde fra a til d: saa kan sættes ad = ab + bc + cd.

§ 3.

Er Summen af flere Længder, Bredder og Høider = 0, saa er Summen af Længderne, den af Bredderne, og den af Høiderne, hver især = 0.

§ 4.

Productet af to rette Linier maa i alle Maader kunne formeres af den ene Factor, som den anden er formeret af den positive eller absolute Linie, der sættes = 1, det er:

Forst maae Factorerne være af den Direction, at de begge kan optages i samme Plan som den positive Unitet.

Dernæst maa i Hensigt til Længden Productet forholde sig til den ene Factor, som den anden til Uniteten; og

Endelig, dersom man giver den positive Unitet, Factorerne og Productet et fælles første Punct, skal Productet i Hensigt til dets Retning ligge i omtalte Unitets og Factorers Plan, og afvige fra den ene Factor ligesaa mange Grader, og til samme Side, som den anden Factor afviger fra Uniteten, saa at Productets Directionsvinkel eller Afvigning fra den positive Unitet, bliver saa stor, som Summen af Factorernes Directionsvinkler.

§ 5.

Lad $+1$ betegne den positive retlinede Unitet, og $+\varepsilon$ en vis anden Unitet, der er perpendicular paa den positive, og har samme Begyndelsespunct: saa er Directionsvinkelen af $+1 = 0$, af $-1 = 180°$, af $+\varepsilon = 90°$, af $-\varepsilon = -90°$ eller $270°$; og i Følge den Regel, at Productets Directionsvinkel er Summen af Factorernes, bliver $(+1).(+1) = +1$, $(+1).(-1) = -1$, $(-1).(-1) = +1$, $(+1).(+\varepsilon) = +\varepsilon$, $(+1).(-\varepsilon) = -\varepsilon$, $(-1).(+\varepsilon) = -\varepsilon$, $(-1).(-\varepsilon) = +\varepsilon$, $(+\varepsilon).(+\varepsilon) = -1$, $(+\varepsilon).(-\varepsilon) = +1$, $(-\varepsilon).(-\varepsilon) = -1$.

Hvoraf sees at ε bliver $= \sqrt{-1}$, og Productets Afvigning bestemmes saaledes, at ei en eneste af de almindelige Operationsregler overtrædes.

§ 6.

Cosinus til en Cirkelbue, der begynder fra det sidste Punct af dens Radius $+1$, er det Stykke af samme, eller modsatte Radius, der begynder fra Centrum, og endes perpendicular udfor Buens sidste Punkt. Sinus til samme Bue drages perpendicular paa Cosinus fra sammes sidste Punct til sidste af buen.

I Følge § 5 er altsaa Sinus til en ret Vinkel $= \sqrt{-1}$. Lad sættes $\sqrt{-1} = \varepsilon$; lad v betegne en Vinkel, hvilken som helst; og lad sin. v bemærke en ret Linie af samme Længde som Vinkelen v's Sinus, men positiv, naar Vinkelens Maal endes i første halve Omkreds, og negativ, naar det endes i den sidste halve: saa følger af § 4 og 5, at ε sin. v udtrykker Vinkelen v's Sinus baade i Hensigt til Direction og Længde.

§ 7.

I Overeensstemmelse med § 1 og 6 er den Radius, som begynder fra Centrum, og afviger fra den absolute eller positive Unitet Vinkelen v, saa stor som $\cos. v + \varepsilon \sin. v$. Men i Følge § 4 skal Productet af to Factorer, hvoraf den ene afviger fra Uniteten Vinkelen v, og den anden Vinkelen u, afvige fra samme Unitet Vinkelen $v + u$. Altsaa naar den rette Linie $\cos. v + \varepsilon \sin. v$ multipliceres med den rette Linie $\cos. u + \varepsilon \sin. u$, bliver Productet en ret Linie, hvis Directionsvinkel er $v + u$. Følgelig kan Productet efter § 1 og 6 betegnes ved $\cos. (v + u) + \varepsilon \sin. (v + u)$.

§ 8.

Dette Product $(\cos. v + \varepsilon \sin. v) . (\cos. u + \varepsilon \sin. u)$ eller $\cos. (v + u) + \varepsilon \sin. (v + u)$ kan endnu udtrykkes paa en anden Maade, nemlig ved at addere i een Sum de partielle Producter, som udkomme, naar hver af de adderte Linier, hvis Sum udgiør den ene Factor, multipliceres med hver af dem, hvis Sum udgiør den anden. Saaledes bliver $(\cos. v + \varepsilon \sin. v) . (\cos. u + \varepsilon \sin. u) = \cos. v \cos. u - \sin. v \sin. u + \varepsilon (\cos. v . \sin. u + \cos. u . \sin. v)$ i Følge de to bekiendte trigonometriske Formler $\cos. (v + u) = \cos. v . \cos. u - \sin. v . \sin. u$, og $\sin. (v + u) = \cos. v . \sin. u + \cos. u . \sin. v$. Disse to Formler kan med Nøiagtighed og uden stor Vidtløftighed bevises for alle Tilfælde, enten hver af Vinklerne v og u, eller een alene er positiv, negativ, større eller mindre end en ret. De Sætninger, som af samme to Formler udledes, har følgelig ogsaa deres Almindelighed.

§ 9.

$\cos. v + \varepsilon \sin. v$ er i Følge § 7 en Cirkels Radius, hvis Længde er $= 1$, og Afvigning fra $\cos. 0°$ er Vinkelen v;

deraf følger at $r \cdot \cos. v + r \cdot \varepsilon \sin. v$ betegner en ret Linie, hvis Længde er r, og hvis Directionsvinkel er $= v$; thi naar en retvinklet Triangels Catheter blive r gange større, saa bliver ogsaa Hypothenusen r gange større, og Vinklerne uforandrede; men Catheternes Sum er i Følge § 1 saa stor som Hypothenusen, altsaa er $r \cdot \cos. v + r \cdot \varepsilon \sin. v = r (\cos. v + \varepsilon \sin. v)$. Dette er altsaa et almindeligt Udtryk for enhver ret Linie, der ligger med Linierne $\cos. 0°$ og $\varepsilon \sin. 90°$ i samme Plan, afviger fra $\cos. 0°$ Graderne v, og har Længden r.

§ 10.

Betegne a, b, c, d directe Linier af hvilken Længde som helst, positive eller negative, og de to indirecte $a + \varepsilon b$ og $c + \varepsilon d$ ligge i samme Plan som den absolute Unitet: saa kan deres Product findes, endogsaa naar deres Afvigning fra den absolute Unitet er ubekiendt; man behøver nemlig kun at multiplicere enhver af de adderte Linier, der udgiøre den ene Sum, med enhver af dem, som udgiøre den anden, saa vil disse Producter adderte udgiøre det søgte Product baade i Henseende til Længden og Retningen; saa at $(a + \varepsilon b) \cdot (c + \varepsilon d) = ac - bd + \varepsilon (ad + bc)$.

Beviis. Lad Liniens $a + \varepsilon b$ Længde være A, og Afvigning fra den absolute Unitet v Grader; men Liniens $c + \varepsilon d$ Længde $= C$, og Afvigning $= u$: saa er, i Følge § 9, $a + \varepsilon b = A \cdot \cos. v + A \cdot \varepsilon \sin. v$, og $c + \varepsilon d = C \cdot \cos. u + C \cdot \varepsilon \sin. u$, altsaa $a = A \cdot \cos. v$, $b = A \cdot \sin. v$, $c = C \cdot \cos. u$, $d = C \cdot \sin. u$ (§ 3); men i Følge § 4 er $(a + \varepsilon b) \cdot (c + \varepsilon d) = A \cdot C \cdot [\cos. (v + u) + \varepsilon \sin. (v + u)] = A \cdot C \cdot [\cos. v \cdot \cos. u - \sin. v \cdot \sin. u + \varepsilon (\cos. v \cdot \sin. u + \cos. u \cdot \sin. v)]$ § 8. Følgelig, naar isteden for $A \cdot C \cdot \cos. u \cdot \cos. v$ sættes $a \cdot c$, isteden for $A \cdot C \cdot \sin. v \cdot \sin. u$ sættes $b \cdot d$, o. s. v.: udkommer det, som skulde bevises.

Hvoraf følger, at skiondt Summens adderte Linier ei alle er directe, saa behøves dog ingen Undtagelse i den bekiendte Regel, hvorpaa Æqvationernes Theorie, og den om hele Functioner og deres *Divisores simplices* grunder sig, nemlig at naar to Summer skal multipliceres med hinanden, da maa enhver af de adderte Størrelser i den ene Sum multipliceres med enhver af de adderte i den anden. Man kan altsaa være forvisset om, at naar en Æqvation angaaer rette Linier, og dens Radix har den Form $a + \varepsilon b$: da betegnes derved en indirect Linie. Men vilde man multiplicere med hinanden rette Linier, som ikke begge kunde ligge i samme Plan med den absolute Unitet: maatte omtalte Regel tilsidesættes. Dette er Aarsagen, hvorfor jeg forbigaaer saadanne Liniers Multiplication. En anden Maade at betegne deres forandrede Retning forekommer i det følgende, § 24—35.

§ 11.

Qvotienten multipliceret med Divisor skal være saa stor som Dividendum. Det behover altsaa ikke Beviis, at disse Linier skal ligge i samme Plan med den absolute Unitet; thi det følger umiddelbar af Definitionen § 4. Ligeledes indsees let, at Qvotienten maa afvige fra den absolute Unitet Vinkelen $\upsilon - u$, dersom Dividendum afviger fra samme Unitet Vinkelen υ, og Divisor Vinkelen u.

Sæt f. Ex. at $A(\cos.\upsilon + \varepsilon\sin.\upsilon)$ skulde divideres med $B(\cos.u + \varepsilon\sin.u)$: da er Qvotienten $= \frac{A}{B}[\cos.(\upsilon - u) + \varepsilon\sin.(\upsilon - u)]$, fordi $\frac{A}{B}[\cos.(\upsilon - u) + \varepsilon\sin.(\upsilon - u)] \times B(\cos.u + \varepsilon\sin.u) = A(\cos.\upsilon + \varepsilon\sin.\upsilon)$, i Følge § 7. Det er, da $\frac{A}{B}[\cos.(\upsilon - u) + \varepsilon\sin.(\upsilon - u)]$ multipliceret med Divisor

$B(\cos. u + \varepsilon \sin. u)$ er saa stor som Dividendum $A(\cos. \upsilon + \varepsilon \sin. \upsilon)$: saa er ogsaa $\frac{A}{B}[\cos. (\upsilon - u) + \varepsilon \sin. (\upsilon - u)]$ den søgte Qvotient.

§ 12.

Ere a, b, c og d directe Linier, og de indirecte $a + \varepsilon b$ og $c + \varepsilon d$ ere i samme Plan med den absolute Unitet: da er $\frac{1}{c + \varepsilon d} = \frac{c - \varepsilon d}{c^2 + d^2}$, og Qvotienten $\frac{a + \varepsilon b}{c + \varepsilon d} = (a + \varepsilon b) . \frac{1}{c + \varepsilon d} = (a + \varepsilon b) . \frac{c - \varepsilon d}{c^2 + d^2} = [ac + bd + \varepsilon(bc - ad)] : (c^2 + d^2)$; thi i Følge § 9 kan sættes $a + \varepsilon b = A(\cos. \upsilon + \varepsilon \sin. \upsilon)$, og $c + \varepsilon d = C(\cos. u + \varepsilon \sin. u)$, altsaa $c - \varepsilon d = C(\cos. u - \varepsilon \sin. u)$, i Følge § 3; og da $(c + \varepsilon d) . (c - \varepsilon d)$ er $= c^2 + d^2 = C^2$ (§ 10): saa er $\frac{c - \varepsilon d}{c^2 + d^2} = \frac{1}{C}(\cos. u - \varepsilon \sin. u)$ § 10, eller $\frac{c - \varepsilon d}{c^2 + d^2} = \frac{1}{C}(\cos. - u + \varepsilon \sin. - u) = \frac{1}{c + \varepsilon d}$ § 11, og naar multipliceres med $a + \varepsilon b = A(\cos. \upsilon + \varepsilon \sin. \upsilon)$, udkommer $(a + \varepsilon b) \frac{c - \varepsilon d}{c^2 + d^2} = \frac{A}{C}[\cos. (\upsilon - u) + \varepsilon \sin. (\upsilon - u)] = \frac{a + \varepsilon b}{c + \varepsilon d}$ § 11.

Indirecte Størrelser af denne Art har altsaa dette fælles med de directe, at naar Dividendum er en Sum af flere Størrelser, da giver enhver af disse divideret med Divisor flere Qvotienter, hvis Sum udgior den søgte Qvotient.

§ 13.

Hvis m er et heelt Tal, frembringer $\cos. \frac{\upsilon}{m} + \varepsilon \sin. \frac{\upsilon}{m}$ multipliceret m gange med sig selv Potenzen $\cos. \upsilon + \varepsilon \sin. \upsilon$.

(§ 7); altsaa $(\cos. \upsilon + \varepsilon \sin. \upsilon)^{\frac{1}{m}} = \cos. \frac{\upsilon}{m} + \varepsilon \sin. \frac{\upsilon}{m}$. Men i Følge § 11 er $\cos. - \frac{\upsilon}{m} + \varepsilon \sin. - \frac{\upsilon}{m} = \frac{1}{\cos. \frac{\upsilon}{m} + \varepsilon \sin. \frac{\upsilon}{m}} = \frac{1}{(\cos. \upsilon + \varepsilon \sin. \upsilon)^{\frac{1}{m}}} = (\cos. \upsilon + \varepsilon \sin. \upsilon)^{-\frac{1}{m}}$, altsaa, enten m er positiv eller negativ, er alletider $\cos. \frac{\upsilon}{m} + \varepsilon \sin. \frac{\upsilon}{m} = (\cos. \upsilon + \varepsilon \sin. \upsilon)^{\frac{1}{m}}$, og derfor, naar m og n begge ere hele Tal, $(\cos. \upsilon + \varepsilon \sin. \upsilon)^{\frac{n}{m}} = \cos. \frac{n}{m} \upsilon + \varepsilon \sin. \frac{n}{m} \upsilon$.

Herved findes Værdien af slige Expressioner som $\sqrt[n]{(b + c\sqrt{-1})}$ eller $\sqrt[m]{(a + \sqrt[n]{(b + c\sqrt{-1})})}$; saaledes kan f. Ex. $\sqrt[3]{(4\sqrt{3} + 4\sqrt{-1})}$ betegne en ret Linie, hvis Længde er $= 2$, og hvis Vinkel med den absolute Unitet maales ved 10°.

§ 14.

Naar to Vinkler have ligestore Sinus og ligestore Cosinus, da er deres Forskiel enten 0, eller $\mp$ 4 rette, eller en Mangefold af $\pm$ 4 rette, og omvendt, naar to Vinklers Forskiel er enten 0, eller $\pm$ 4 rette, een eller flere gange tagne, da er deres Sinus saavelsom deres Cosinus ligestore.

§ 15.

Er m et heelt Tal, og $\pi = 360°$, saa har $(\cos. \upsilon + \varepsilon \sin. \upsilon)^{\frac{1}{m}}$ kun følgende m forskiellige Værdier:

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$\cos.\frac{\upsilon}{m} + \varepsilon \sin.\frac{\upsilon}{m}$, $\cos.\frac{\pi+\upsilon}{m} + \varepsilon\sin.\frac{\pi+\upsilon}{m}$, $\cos.\frac{2+\upsilon}{m} +$
$\varepsilon\sin.\frac{2+\upsilon}{m}$, ... , $\cos.\frac{(m-1)\pi+\upsilon}{m} +$
$\varepsilon\sin.\frac{(m-1)\pi+\upsilon}{m}$;

thi de Tal, hvormed π er multipliceret i foregaaende Række, ere i en arithmetisk Progression 1, 2, 3, 4 . . . m — 1. Altsaa er Summen af hver to = m, naar det ene er ligesaa langt fra 1, som det andet er fra m — 1, og er deres Antal ueffent, bliver to Gange det Midterste = m; derfor, naar adderes $\frac{(m-n)\pi+\upsilon}{m}$ til $\frac{(m-u)\pi+\upsilon}{m}$, og denne er i Rækken ligesaa langt fra $\frac{\pi+\upsilon}{m}$, som $\frac{(m-n)\pi+\upsilon}{m}$ er fra $\frac{(m-1)\pi+\upsilon}{m}$: saa er Summen $=\frac{2m-u-n}{m}\pi+\frac{2\upsilon}{m}=\pi+\frac{2\upsilon}{m}$; men at addere $\frac{(m-n)\pi}{m}$ er det samme som at subtrahere $\frac{(m-n)(-\pi)}{m}$; og da Differencen bliver π: saa har, i Følge § 14, $\frac{(m-n).(-\pi)+\upsilon}{m}$ samme Cosinus og Sinus som $\frac{(m-u)\pi+\upsilon}{m}$; ligeledes har $\frac{(m-u).(-\pi)+\upsilon}{m}$ samme Cosinus og Sinus som $\frac{(m-n)\pi+\upsilon}{m}$; altsaa giver $-\pi$ ei andre Værdier end $+\pi$. Men at ingen af disse ere ligestore følger deraf: at Forskiellen mellem to af Rækkens Vinkler alletider er mindre end π, og aldrig = 0. Der findes ei heller flere Værdier ved at fortsætte Rækken; thi da bliver Vinklerne $\pi+\frac{\upsilon}{m}$, $\pi+\frac{\pi+\upsilon}{m}$, $\pi+\frac{2\pi+\upsilon}{m}$ o. s. v., altsaa i Følge § 14 Værdierne af deres Cosinus og Sinus de samme som før. Skulde Vinklerne falde udenfor Rækken, blev i Tælleren ei π multipliceret med et heelt Tal, og Vinklerne vilde da m gange tagne ei kunne frembringe en Vinkel, der subtraheret fra υ gav 0, eller $\pm\ \pi$, eller en Mangfoldighed af $\mp\ \pi$, altsaa kunde ei heller den mte Potenz af slig en Vinkels Cosinus tilligemed Sinus blive $= \cos.\upsilon + \varepsilon \sin.\upsilon$.

§ 16.

Uden at vide Vinkelen, som den indirecte Linie $1 + x$ giør med den absolute, findes, naar Længden af x er mindre end 1, Digniteten $(1+x)^m = 1 + \frac{mx}{1} + \frac{m}{1} . \frac{m-1}{2} . x^2 + \&c.$, og dersom denne Række ordnes efter Potenzerne af m, beholder den samme Størrelse, og forvandles til $1 + \frac{ml}{1} + \frac{m^2 l^2}{1.2} + \frac{m^3 l^3}{1.2.3} + \&c.$, hvori $l = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \&c.$, og er en Sum af en direct og en perpendicular Linie; kaldes den directe a, og den perpendiculare $b\sqrt{-1}$: da er b det mindste Maal til Vinkelen, som $1 + x$ giør med $+ 1$, og sættes $1 + \frac{1}{1} + \frac{1}{1.2} + \frac{1}{1.2.3} + \&c. = e$, kan $(1 + x)^m$ eller $1 + \frac{ml}{1} + \frac{m^2 l^2}{1.2} + \frac{m^3 l^3}{1.2.3} + \&c.$ betegnes ved $e^{ma + mb\sqrt{-1}}$, det er $(1+x)^m$ har Længden e^{ma}, og en Directionsvinkel, hvis Maal er mb, forudsat m at være positiv eller negativ. Saaledes kan Directionen af Linier i samme Plan endnu udtrykkes paa en anden Maade, nemlig ved Hielp af de naturlige Logarithmer. Fuldstændigt Beviis for disse Sætninger vil jeg en anden Gang, om det tilstædes mig, fremlægge. Nu, da jeg har giort Regnskab for, paa hvad Maade rette

Liniers Sum, Product, Qvotient og Dignitet efter min Mening findes, vil jeg alene give et Par Exempler paa Methodens Anvendelse.

II.

Beviis for den Cotesianske Læresætning.

§ 17.

Jeg forudsætter som bekiendt, at naar Æqvationen $x^n + px^{n-1} + qx^{n-2} + \ldots + sx + t = 0$ har de n Radices a, b, c ... g: da har den hele Function $z^n + pz^{n-1} + qz^{n-2} + \ldots + sz + t$ de *Divisores simplices* $z - a$, $z - b$, $z - c$ ... $z - g$, og er et Product af dem alle.

§ 18.

Den af Cotes opfundne Sætning er følgende:

Naar Buerne ab, bc, cd, de, ea (Fig. 1) ere i Tallet n, og indeholder Graderne $\frac{360}{n} = \frac{\pi}{n}$, og Radius oa sættes $= r$, $ao = - r$, $op = z$, $po = - z$, og p er det sidste Punct i Linierne ap, bp, cp, dp, ep: saa er $ap . bp . cp . dp . ep = z^n - r^n$; Thi af § 1 og § 9 følger

$$\text{at } ap = z - r$$

$$bp = z - r\left(\cos.\frac{\pi}{n} + \varepsilon \sin.\frac{\pi}{n}\right)$$

$$cp = z - r\left(\cos.\frac{2\pi}{n} + \varepsilon \sin.\frac{2\pi}{n}\right)$$

$$dp = z - r\left(\cos.\frac{3\pi}{n} + \varepsilon \sin.\frac{3\pi}{n}\right)$$

$$ep = z - r\left(\cos.\frac{4\pi}{n} + \varepsilon \sin.\frac{4\pi}{4}\right)$$

$$\text{eller } ep = z - r\left(\cos.\frac{(n-1)\pi}{n} + \varepsilon \sin.\frac{(n-1)\pi}{n}\right)$$

og af § 15 sluttes, at Æqationens $x^n - r^n = 0$ Radices ere

$$r,\ r\left(\cos.\frac{\pi}{n} + \varepsilon \sin.\frac{\pi}{n}\right),\ r\left(\cos.\frac{2\pi}{n} + \varepsilon \sin.\frac{2\pi}{n}\right),$$

$$..\ r\left(\cos.\frac{(n-1)\pi}{n} + \varepsilon \sin.\frac{(n-1)\pi}{n}\right);$$

altsaa bliver i Følge § 17 $z^n - r^n = ap\,.\,bp\,.\,cp\,.\,dp\,.\,ep$. Følgelig er Længden af $z^n - r^n$ saa stor som Productet af Liniernes ap, bp, cp &c. Længder, § 4.

Om plane Polygoners Opløsning.

§ 19.

Følgende af Trigonometrien bekiendte Formler anfører jeg uden Beviis.

a) $\sin.(a+b) = \sin.a\,.\,\cos.b + \sin.b\,.\,\cos.a.$

b) $\cos.(a+b) = \cos.a\,.\,\cos.b - \sin.a\,.\,\sin.b.$

c) $\sin.2a = 2\sin.a\,.\,\cos.a.$

d) $1 + \cos.2a = 2\cos.^2 a.$

e) $1 - \cos.2a = 2\sin^2 a.$

f) $\text{tang}.a = \dfrac{\sin.2a}{1+\cos.2a}.$

g) $\sin.a + \sin.b = 2\sin.\dfrac{a+b}{2}\,.\,\cos.\dfrac{a-b}{2}.$

h) $\sin.a - \sin.b = 2\cos.\dfrac{a+b}{2}\,.\,\sin.\dfrac{a-b}{2}.$

i) $\cos.b - \cos.a = 2\sin.\dfrac{a+b}{2}\,.\,\sin.\dfrac{a-b}{2}.$

k) $\dfrac{\sin.a + \sin.b}{\cos.a + \cos.b} = \text{tang}.\dfrac{a+b}{2}.$

l) $\frac{\sin. a - \sin. b}{\cos. a + \cos. b} = \text{tang.} \frac{a-b}{2}$.

§ 20.

Til Polygoners Opløsning kan det ogsaa være tienligt at erindre sig: naar et Problem er bragt dertil, at man har $a = b \cos. u + c \sin. u$, og u alene er den ubekiendte, da kan den qvadratiske Æqvation, hvorved sin u eller cos. u skulde findes, undgaaes ved at sætte $\frac{b}{c} = \text{tang.} \varphi$, eller $\frac{b}{c} = \cot. \psi$. Derved findes φ eller ψ, som bliver positiv eller negativ, og behøver ei at være større end 90°. Er φ eller ψ funden søges derefter u ved en af følgende Æqvationer: $\sin. (u + \varphi) = a \sin. \varphi : b = a \cos. \varphi : c$, og $\cos. (u - \psi) = \cos. (\psi - u) = \frac{a \cos. \psi}{b} = \frac{a \sin. \psi}{c}$; Thi naar Ledene i den givne Ævation $a = b \cos. u + c \sin. u$ divideres med c, eller med b, og derefter isteden for $\frac{b}{c}$ sættes dens Værdi $\text{tang.} \varphi$, eller $\cot. \psi$, og isteden for $\frac{c}{b}$ sættes $\cot. \varphi$ eller $\text{tang.} \psi$, udkommer:

$$\frac{a}{c} = \text{tang.} \varphi . \cos. u + \sin. u = \cot. \psi . \cos. u + \sin. u, \text{ eller}$$

$$\frac{a}{b} = \cos. u + \cot. \varphi . \sin. u = \cos. u + \text{tang.} \psi . \sin. u.$$

Følgelig, naar Ledene i den første af disse Ævationer multipliceres med $\cos. \varphi$, i den anden med $\sin. \psi$, i den tredie med $\sin. \varphi$, og den fierde med $\cos. \psi$, faaes

$$\frac{a}{c} \cos. \varphi = \sin. \varphi . \cos. u + \cos. \varphi . \sin. u,$$

$$\frac{a}{c}\sin.\psi = \cos.\psi.\cos.u + \sin.u.\sin.\psi,$$

$$\frac{a}{b}\sin.\varphi = \sin.\varphi.\cos.u + \cos.\varphi.\sin.u,$$

$$\frac{a}{b}\cos.\psi = \cos.\psi.\cos.u + \sin.u.\sin.\psi;$$

altsaa er, i Følge § 19, *a*, *b*,

$$\frac{a\cos.\varphi}{c} = \sin.(u + \varphi),\ \frac{a\sin.\psi}{c} = \cos.(u - \psi) = \cos.(\psi - u),$$

og $\frac{a\sin.\varphi}{b} = \sin.(u + \varphi),\ \frac{a\cos.\psi}{b} = \cos.(u - \psi) = \cos.(\psi - u).$

§ 21.

Naar i et plant Polygon intet mere gives end alle Vinklerne, og Siderne saa nær som tre: da er Polygonet ubestemt. Dette er tydeligt nok, hvis alle tre ubekiendte Sider følger efter hinanden; thi da kan med den ene ubekiendte Side drages Paralleler, som skiære de to andre ubekiendte i flere Puncter, og disse tre Sider kan altsaa have utallig mange Værdier; men deraf følger ogsaa, at de tre ubekiendte Sider kan have ligesaa, mange Værdier, endskiøndt de ikke følge efter hinanden; thi da Sidernes Orden er i Hensigt til deres Sum ligegyldig (§ 2): saa kan af ethvert Polygon alletider construeres et andet, hvori Sidernes Længde og Retning er den samme, men deres Orden alene forskiellig.

§ 22.

I et Polygon abcd (Fig. 2) antages den ene Side ab for absolut, og tælles fra a til b, den anden bc tælles fra b til c, cd fra c til d, da fra d til a; de efne Tal II, IV, VI, viii bemærke Sidernes Længder; de uefne i, iii, v, vii, ere deres Afvigninger fra foregaaende Sides Forlængning talte positive eller negative; f. Ex. med Solen positive, og mod Solen negative.

i′, iii′, v′, vii′ betegne $\cos.\,\text{i} + \varepsilon\sin\,\text{i}$, $\cos.\,\text{iii} + \varepsilon\sin.\,\text{iii}$, $\cos.\,\text{v} + \varepsilon\sin.\,\text{v}$ o. s. v.

$\bar{\text{i}}'$, $\overline{\text{iii}}'$, $\bar{\text{v}}'$, $\overline{\text{vii}}'$ betegne $\cos. -\text{i} + \varepsilon\sin. -\text{i}$, $\cos.\,\text{iii} - \varepsilon\sin.\,\text{iii}$, $\cos.\,\text{v} - \varepsilon\sin.\,\text{v}$ &c.

Naar dette forudsættes, og man fra a drager Paralleler med bc, cd, da: saa følger,

I) At første Parallel afviger fra ab Graderne iii, anden Parallel fra ab Graderne iii + v, tredie Parallel eller sidste Sides da Forlængning ae afviger fra ab Graderne iii + v + vii eller — i. Derfor bliver alle Vinklerne tilsammen = 0, og Maalet til deres Sum bliver enten 0, eller $\mp$ 4 rette, eller en Mangefold deraf.

II) $\text{ii} + \text{iv}\,.\,\text{iii}' + \text{vi}\,.\,\text{iii}'\,.\,\text{v}' + \text{viii}\,.\,\text{iii}'\,.\,\text{v}'\,.\,\text{vii}' = 0$; thi ab + bc + cd + da = 0 (§ 2); men ab = ii, bc = iv . iii′ (§ 9), cd = $\text{vi}\,[\cos.\,(\text{iii} + \text{v}) + \varepsilon\sin.\,(\text{iii} + \text{v})]$, i Følge foregaaende Numer *I* og § 9, altsaa er efter § 7 cd = vi . iii′ . v′, og ligeledes bevises at da er = viii . iii′ . v′ . vii′.

III) $\text{ii}\,.\,\text{iii}'\,.\,\text{v}'\,.\,\text{vii}' + \text{iv}\,.\,\text{v}'\,.\,\text{vii}' + \text{vi}\,.\,\text{vii}' + \text{viii} = 0$; thi naar Ledene i foregaaende Æqvation *II* divideres med iii′ . v′ . vii′, udkommer i Følge § 12 $\text{ii}\,.\,\overline{\text{iii}}'\,.\,\bar{\text{v}}'\,.\,\overline{\text{vii}}' + \text{iv}\,.\,\bar{\text{v}}'\,.\,\overline{\text{vii}}' + \text{vi}\,.\,\overline{\text{vii}}' + \text{viii} = 0$, og da ethvert Led i denne Æqvation, saa nær som det sidste, er multipliceret med en Cosinus tilligemed en Sinus, (første Led f. Ex. er = $\text{ii}\,[\cos.\,(\text{iii} + \text{v} + \text{vii}) - \varepsilon\sin.\,(\text{iii} + \text{v} + \text{vii})]$); men Summen af alle de directe Led er ligesaavel = 0, som

Summen af de Led, der ere multiplicerede med Sinus, § 3: saa bliver den totale Sum endnu $= 0$, endskiøndt hver Sinus faaer modsat Retning, og naar dette skeer, forvandles Udtrykket til det, som skulde bevises.

IV) $\mathrm{III}' + \mathrm{II\bar{I}}' = 2 \cos. \mathrm{III}$, $\mathrm{III}' . \mathrm{V}' + \mathrm{II\bar{I}}' . \mathrm{\bar{V}}' = 2 \cos. (\mathrm{III} + \mathrm{V})$, $\mathrm{III}' . \mathrm{\bar{V}}' + \mathrm{II\bar{I}}' . \mathrm{V}' = 2 \cos. (\mathrm{III} - \mathrm{V})$, $\mathrm{III}' - \mathrm{II\bar{I}}' = 2\, \varepsilon \sin. \mathrm{III}$, $\mathrm{III}' . \mathrm{V}' - \mathrm{II\bar{I}}' . \mathrm{\bar{V}}' = 2\, \varepsilon \sin. (\mathrm{III} + \mathrm{V})$, $\mathrm{III}' . \mathrm{\bar{V}}' - \mathrm{II\bar{I}}' . \mathrm{V}' = 2\, \varepsilon \sin. (\mathrm{III} - \mathrm{V})$, $\frac{(\mathrm{III}')^2 - 1}{(\mathrm{III}')^2 + 1} = \varepsilon \text{ tang. } \mathrm{III} = \frac{1 - (\mathrm{II\bar{I}}')^2}{1 + (\mathrm{II\bar{I}}')^2}$, $\frac{(\mathrm{III}')^2 + 1}{(\mathrm{III}')^2 - 1} = - \varepsilon \cot. \mathrm{III} = \frac{1 + (\mathrm{II\bar{I}}')^2}{1 - (\mathrm{II\bar{I}}')^2}$, af hvilke Formler Rigtigheden let indsees ved at sætte isteden for III', $\mathrm{II\bar{I}}'$, V', $\mathrm{\bar{V}}'$ deres Værdier $\cos. \mathrm{III} + \varepsilon \sin. \mathrm{III}$, $\cos. \mathrm{III} - \varepsilon \sin. \mathrm{III}$, $\cos. \mathrm{V} + \varepsilon \sin. \mathrm{V}$, &c.

§ 23.

To Æqvationer af den Form som *II* og *III* i foregaaende Paragraph ere tilstrækkelige til ethvert Polygons Opløsning, naar kun tre Vinkler, eller to Vinkler og een Side, eller een Vinkel og to Sider ere ubekiendte; thi i det sidste Tilfælde har den ubekiendte Vinkel samme Cosinus og Sinus, som det modsatte af de øvrige Vinklers Sum (§ 22 No. *I*); i de to andre Tilfælde udelukkes af Ævationerne den ene ubekiendte Vinkel, naar den betegnes ved I ligesom i § 22 No. *II* og No. *III*: Følgelig indeholde Æqvationerne kun to ubekiendte Stykker. Altsaa kan findes, hvad Function det ene Stykke er af det andet ved Hielp af den ene Ligning; denne Function indført i den anden Ligning befrier samme fra det ene ubekiendte Stykke, og derved findes tilsidst Værdien af det andet.

Lad f. Ex. i Polygonet Fig. 2. I, III, VI være ubekiendte og III søges, da er i Følge § 22 No. *II* og No. *III*: $\text{II} + \text{IV} \,.\, \text{III}' + \text{VI} \,.\, \text{III}' \,.\, \text{V}' + \text{VIII} \,.\, \text{III}' \,.\, \text{V}' \,.\, \text{VII}' = 0 = \text{II} \,.\, \text{III}' \,.\, \text{V}' \,.\, \text{VII}' + \text{IV} \,.\, \text{V}' \,.\, \text{VII}' + \text{VI} \,.\, \text{VII}' + \text{VIII}$. Af den første Æqvation findes $- \text{II} \,.\, \text{III}^{-\prime} \,.\, \text{V}^{-\prime} - \text{IV} \,.\, \text{V}^{-\prime} - \text{VIII} \,.\, \text{VII}' = \text{VI}$, og naar denne Værdie af VI indføres i den anden Æqvation, efterat sammes Led er dividerte med VII', udkommer $\text{II} \,.\, \text{III}' \,.\, \text{V}' - \text{II} \,.\, \text{III}^{-\prime} \,.\, \text{V}^{-\prime} + \text{IV} \,.\, \text{V}' - \text{IV} \,.\, \text{V}^{-\prime} + \text{VIII} \,.\, \text{VII}^{-\prime} - \text{VIII} \,.\, \text{VII}' = 0$. Altsaa i Følge § 22 No. *IV*, $\text{II} \,.\, \varepsilon \,.\, 2 \sin.\, (\text{III} + \text{V}) + \text{VI} \,.\, \varepsilon \,.\, 2 \sin.\, \text{V} - \text{III}\, \varepsilon \,.\, 2 \sin.\, \text{VII} = 0$, eller $\sin.\, (\text{III} + \text{V}) = \dfrac{\text{VIII} \,.\, \sin.\, \text{VII} - \text{IV} \,.\, \sin.\, \text{V}}{\text{II}}$.

III.

Hvordan Directionen af en Kugles Radii kan betegnes

§ 24.

Jeg antager, at en Kugles to horizontale Radii giøre rette Vinkler med hinanden, og ere begge perpendiculare paa en tredie Kuglens Radius. Den ene horizontale sætter jeg at strække sig fra Centrum til venstre Haand, og at være $= r$; den anden horizontale at gaae fra Centrum fremad, og at være $= \varepsilon . r$; men den verticale fra Centrum opad at være $= \eta . r$, og de modsatte at være $- r$, $- \varepsilon r$, $- \eta r$. Ved Bogstaven r betegnes Længden af Radius; Uniteterne ε og η ere begge perpendiculare paa $+ 1$, og i Sammenligning med denne maa η^2 saavelsom ε^2 være $= - 1$, i Følge § 5.

§ 25.

Drages der et Plan igiennem de fire Radii r, $- r$, $r\eta$, $- \eta r$, og et andet igiennem r, $- r$, εr, $- \varepsilon r$, da giøre disse Planer en ret Vinkel med hinanden, og overskiære Kuglen i to Storcirkler, af hvilke jeg kalder den igiennem r og $r\eta$ Verticalcirkelen, og den igiennem de horizontale Radii r og εr Horizonten.

Buerne i Verticalen og dens Paralleler tælles fra det Punct paa venstre Haand, hvor de overskiæres af Horizonten, opad positive, nedad negative. De horizontale Buer tælles fra Verticalen med Solen positive, og mod Solen negative. Naar f. Ex. $ow\gamma hpi$ (Fig. 3) betegner Horizonten, $kfs\beta$ dens Parallel, $ok\pi qnu$ Verticalen, π og n Horizontens Poler, p og γ Verticalens: saa antages $co = r$, $ct = -r$, $c\gamma = \varepsilon r$, $cp = -\varepsilon r$, $c\pi = \eta r$, $cn = -\eta r$, $o\gamma = +90°$, $op = -90°$, $o\pi = +90°$, $on = -90°$; og Buerne i Parallelen tælles den Vei fra k til venstre positive, og fra k til høire negative.

§ 26.

Trækkes der fra Kuglens Centrum c (Fig. 3) til et Punct d i Horizontens og Verticalens fælles Radius en Linie cd og fra dennes yderste Punct d drages en anden de, som er parallel med Horizontens Axel πn, og atter fra Enden af denne trækkes en tredie Linie ef parallel med Verticalens Axel $p\gamma$: da ere disse tre Linier Coordinater til det Punct f, hvor den sidste Linie ef endtes. Den første cd er Punctet f's Abscisse, og betegnes ved x; den er enten af samme Retning som Radius $+r$, eller den er negativ som Radius $-r$. Den anden og tredie Linie de og ef ere Punctet f's Ordinater; ved den anden de forestilles Punktet f's Afstand fra Horizontens Plan; den betegnes ved ηy, fordi den er parallel med ηr eller med $-\eta r$. Den tredie ef er Punctet f's Afstand fra Verticalens Plan, og betegnes ved εz, fordi den er parallel med Radius εr eller $-\varepsilon r$. Den tredie ef ($= \varepsilon z$) giør en ret Vinkel med den anden de

($=\eta y$), og denne ηy giør en ret Vinkel med den første cd ($=$ x).

§ 27.

En Radius, hvis yderste Punct har de Coordinater x, ηy og εz, betegner jeg ved Summen $x + \eta y + \varepsilon z$ (§ 2). $x + \eta y$ multipliceres med $a + \eta b$, og $x + \varepsilon z$ med $a + \varepsilon b$ paa samme Maade som $c + d\sqrt{-1}$ med $a + b\sqrt{-1}$; thi da Directionsvinklerne af η og af ε tælles begge fra samme Radius $+1$ (§ 25), saa maa i Følge § 5 saavel η^2, som ε^2 være $= -1$, og altsaa findes Producterne $(x + \eta y) . (a + \eta b)$ og $(x + \varepsilon z) . (a + \varepsilon b)$ efter den Regel § 10.

§ 28.

Dersom et Punct rykker frem eller tilbage i en horizontal Cirkels Omkreds βkfs (Fig. 3) et vist Antal Grader fs ($=$ III), og dets Coordinater vare cd ($= x'$), de ($= \eta y'$), og ef ($= \varepsilon z'$): da bliver Ordinaten $\eta y'$ uforandret, fordi Punctet beholder samme Afstand fra Horizonten; men Abscissen cd ($=$ ue) eller x' forandres til ul ($= x''$), og Ordinaten ef ($= \varepsilon z'$) forandres til ls ($= \varepsilon z''$), og Summen af de to nye Coordinater ul $+$ ls ($= x'' + \varepsilon z''$) bliver $(x' + \varepsilon z') . (\cos. \text{III} + \varepsilon \sin. \text{III})$; thi lad Radius uk kaldes ρ, Maalet til Vinkelen kuf kaldes I, altsaa Maalet til Vinkelen kus $= \text{I} + \text{III}$: saa er i Følge § 9 ue $+$ ef $(= x' + \varepsilon z') = \rho . (\cos. \text{I} + \varepsilon \sin. \text{I})$; ligeledes er ul $+$ ls $(= x'' + \varepsilon z'') = \rho . [\cos. (\text{I} + \text{III}) + \varepsilon \sin. (\text{I} + \text{III})] = \rho (\cos. \text{I} + \varepsilon \sin. \text{I}) . (\cos. \text{III} + \varepsilon \sin. \text{III})$, § 8; og altsaa, naar isteden for $\rho (\cos. \text{I} + \varepsilon \sin. \text{I})$ sættes $x' + \varepsilon z'$, faaes $x'' + \varepsilon z'' = (x' + \varepsilon z') . (\cos. \text{III} + \varepsilon \sin. \text{III})$.

§ 29.

Naar et Punct beskriver i Verticalen eller dens Parallel en Bue af et vist Antal Grader II, saa forandres Summen af dets forrige Coordinater x' og $\eta y'$ til $(x' + \eta y') \cdot (\cos. \text{II} + \eta \sin. \text{II})$; men den tredie Coordinat $\varepsilon z'$ bliver uforandret, fordi Afstanden fra Verticalen kan ei forandres, saalænge Punctet bliver i Verticalens Parallel. Forresten er Beviset i Følge § 27 netop som det foregaaende.

§ 30.

Har Kuglens Radius de Coordinater x, ηy og εz, da betegnes denne Radius i Følge § 27 ved $x + \eta y + \varepsilon z$. Men forandres dens Direction saaledes, at dens yderste Punct forflyttes de horizontale Grader I: bliver den $= \eta y + (x + \varepsilon z) \cdot (\cos. \text{I} + \varepsilon \sin. \text{I}) = \eta y + x \cos. \text{I} - z \sin. \text{I} + \varepsilon x \sin. \text{I} + \varepsilon z \cos. \text{I}$ (§ 28), og betegnes ved $(x + \eta y + \varepsilon z)$ „ $(\cos. \text{I} + \varepsilon \sin. \text{I})$.

§ 31.

Forandres derimod Directionen af Radius $x + \eta y + \varepsilon z$: ved at forflytte dens sidste Punct de verticale Grader II, bliver den $= \varepsilon z + (x + \eta y) \cdot (\cos. \text{II} + \eta \sin. \text{II}) = \varepsilon z + x \cos. \text{II} - y \sin. \text{II} + \eta x \sin. \text{II} + \eta y \cos. \text{II}$ (§ 29), og betegnes ved $(x + \eta y + \varepsilon z)$ „ $(\cos. \text{II} + \eta \sin. \text{II})$.

§ 32.

Hvoraf følger, at $(x + \eta y + \varepsilon z)$ „ $(\cos. \text{I} + \varepsilon \sin. \text{I})$ „ $(\cos. \text{III} + \varepsilon \sin. \text{III})$ er det samme som $(x + \eta y + \varepsilon z)$ „ $(\cos. (\text{I} + \text{III}) + \varepsilon \sin (\text{I} + \text{III}))$; thi enten det sidste Punct af Radius $x + \eta y + \varepsilon z$ gaaer først frem de horizontale Grader I, og derefter de horizontale Grader III, eller det gaaer paa eengang frem den hele Bue I + III: saa bliver Radius fra Centrum c til sidste Punct i Buen III den samme. Ligeledes følger, at $(x + \eta y + \varepsilon z)$ „ $(\cos. \text{II} + \eta \sin. \text{II})$ „ $(\cos. \text{IV}$

$+ \eta \sin \text{IV}) = (x + \eta y + \varepsilon z) \text{„} (\cos. (\text{II} + \text{IV}) + \eta \sin. (\text{II} + \text{IV}))$, og altsaa $x + \eta y + \varepsilon z = (x + \eta y + \varepsilon z) \text{„} (\cos. \text{I} + \varepsilon \sin. \text{I}) \text{„} (\cos. \text{I} - \varepsilon \sin. \text{I}) = (x + \eta y + \varepsilon z) \text{„} (\cos. \text{II} + \eta \sin. \text{II}) \text{„} (\cos. \text{II} - \eta \sin. \text{II})$.

§ 33.

Gaaer et Punct frem deels i Horizontens, deels i Verticalens Paralleler, beskrivende vexelviis en horizontal og en vertical Bue; men de beskrevne Buers Grader, i den Orden som de følge hinanden, betegnes ved I, II, III, IV, V, VI; og Radius fra Centrum af Kuglen (Fig. 4) til første Punct i første Bue betegnes ved s; Radius fra Centrum til sidste Punct i sidste Bue ved S; og $\cos. \text{I} + \varepsilon \sin. \text{I}$ betegnes ved I', $\cos. \text{II} + \eta \sin. \text{II}$ ved II', $\cos. \text{III} + \varepsilon \sin. \text{III}$ ved III' o. s. f.: samt $\cos. \text{I} - \varepsilon \sin. \text{I}$ ved $\text{I}^{-\prime}$, $\cos. \text{II} - \eta \sin. \text{II}$ ved $\text{II}^{-\prime}$ o. s. f.: saa er, i Følge § 30 og 31, $S = s \text{„} \text{I}' \text{„} \text{II}' \text{„} \text{III}' \text{„} \text{IV}' \text{„} \text{V}' \text{„} \text{IV}'$, i hvilken Æqvations sidste Led Uniteterne IV', V', VI', eller saa mange man vil af de sidste, der umiddelbar følge hinanden, kan borttages, naar deres reciproqve Størrelser sammenføiede ved Tegnet (”) i inverteret Orden tilføies første Led; det er, man kan i Følge § 32 sætte $S \text{„} \text{VI}^{-\prime} \text{„} \text{V}^{-\prime} \text{„} \text{IV}^{-\prime} = s \text{„} \text{I}' \text{„} \text{II}' \text{„} \text{III}'$, eller $s \text{„} \text{I}' \text{„} \text{II}' = S \text{„} \text{VI}^{-\prime} \text{„} \text{V}^{-\prime} \text{„} \text{IV}^{-\prime} \text{„} \text{III}^{-\prime}$ o. s. f.

§ 34.

Antages $s = S$, og sættes $s = \eta r$, bliver derfor

$$s \text{„} \text{I}' = \eta r$$

$$I)\quad s \text{„} \text{I}' \text{„} \text{II}' = r . (\eta \cos. \text{II} - \sin. \text{II}) = S \text{„} \text{VI}^{-\prime} \text{„} \text{V}^{-\prime} \text{„} \text{IV}^{-\prime} \text{„} \text{III}^{-\prime} =$$

$$r . \begin{Bmatrix} \text{cIII.cIV.cV.ſVI} + \eta.\text{cIV.cVI} - \varepsilon.\text{ſIII.cIV.cV.ſVI} \\ + \text{cIII.ſIV.cVI} - \eta.\text{ſIV.cV.ſVI} - \varepsilon.\text{ſIII.ſIV.cVI} \\ - \text{ſIII.ſV.ſVI} - \varepsilon.\text{cIII.ſV.ſVI} \end{Bmatrix} .$$

II) $$s\text{„}\mathrm{I}'\text{„}\mathrm{II}'\text{„}\mathrm{III}' = r.(\eta.\mathrm{cII} - \text{ſ}\mathrm{II}.\mathrm{cIII} - \varepsilon.\text{ſ}\mathrm{II}.\text{ſ}\mathrm{III}) = S\text{„}\overline{\mathrm{VI}}'\text{„}\overline{\mathrm{V}}'\text{„}\overline{\mathrm{IV}}' =$$

$$r.\left\{\begin{matrix} \mathrm{cIV}.\mathrm{cV}.\text{ſ}\mathrm{VI} - \varepsilon.\text{ſ}\mathrm{V}.\text{ſ}\mathrm{VI} + \eta.\mathrm{cIV}.\mathrm{cVI} \\ + \text{ſ}\mathrm{IV}.\mathrm{cVI} \qquad\qquad - \eta.\text{ſ}\mathrm{IV}.\mathrm{cV}.\text{ſ}\mathrm{VI} \end{matrix}\right\}.$$

III) $$s\text{„}\mathrm{I}'\text{„}\mathrm{II}'\text{„}\mathrm{III}'\text{„}\mathrm{IV}' =$$

$$r.\left\{\begin{matrix} \eta.\mathrm{cII}.\mathrm{cIV} & - \mathrm{cII}.\text{ſ}\mathrm{IV} & - \varepsilon.\text{ſ}\mathrm{II}.\text{ſ}\mathrm{III} \\ - \eta.\text{ſ}\mathrm{II}.\mathrm{cIII}.\mathrm{cIV} & - \text{ſ}\mathrm{II}.\mathrm{cIII}.\mathrm{cIV} & \end{matrix}\right\} =$$

$$S\text{„}\overline{\mathrm{IV}}'\text{„}\overline{\mathrm{V}}' = r.(\mathrm{cV}.\text{ſ}\mathrm{VI} - \varepsilon.\text{ſ}\mathrm{V}.\text{ſ}\mathrm{VI}. + \eta.\mathrm{cVI}).$$

IV) $$s\text{„}\mathrm{I}'\text{„}\mathrm{II}'\text{„}\mathrm{III}'\text{„}\mathrm{IV}'\text{„}\mathrm{V}' =$$

$$r.\left\{\begin{matrix} \eta.\mathrm{cII}.\mathrm{cIV} & - \mathrm{cII}.\text{ſ}\mathrm{IV}.\mathrm{cV} & - \varepsilon.\mathrm{cII}.\text{ſ}\mathrm{IV}.\text{ſ}\mathrm{V} \\ + \eta\text{ſ}\mathrm{II}.\mathrm{cIII}.\mathrm{cIV} & - \text{ſ}\mathrm{II}.\mathrm{cIII}.\mathrm{cIV}\mathrm{cV} & - \varepsilon.\text{ſ}\mathrm{II}.\mathrm{cIII}.\mathrm{cIV}.\text{ſ}\mathrm{V} \\ & + \text{ſ}\mathrm{II}.\text{ſ}\mathrm{III}.\text{ſ}\mathrm{V} & - \varepsilon.\text{ſ}\mathrm{II}.\text{ſ}\mathrm{III}.\mathrm{cV} \end{matrix}\right\}$$

$$= S\text{„}\overline{\mathrm{VI}}' = r.(\eta.\mathrm{cVI} + \text{ſ}\mathrm{VI}).$$

§ 35.

Sættes $s = S = \varepsilon r$, faaes følgende Æqvationer:

I) $$s\text{„}\mathrm{I}' = r.(\varepsilon.\mathrm{cI} - \text{ſ}\mathrm{I}) = S\text{„}\overline{\mathrm{VI}}'\text{„}\overline{\mathrm{V}}'\text{„}\overline{\mathrm{IV}}'\text{„}\overline{\mathrm{III}}'\,\overline{\mathrm{II}}' =$$

$$r.\left\{\begin{matrix} \varepsilon.\mathrm{cIII}.\mathrm{cV} & + \mathrm{cII}.\text{ſ}\mathrm{III}.\mathrm{cV} & - \eta.\text{ſ}\mathrm{II}.\text{ſ}\mathrm{III}.\mathrm{cV} \\ - \varepsilon.\text{ſ}\mathrm{III}.\mathrm{cIV}.\text{ſ}\mathrm{V} & + \mathrm{cII}.\mathrm{cIII}.\mathrm{cIV}.\text{ſ}\mathrm{V} & - \eta.\text{ſ}\mathrm{II}.\mathrm{cIII}.\mathrm{cIV}.\text{ſ}\mathrm{V} \\ & - \text{ſ}\mathrm{II}.\text{ſ}\mathrm{IV}.\text{ſ}\mathrm{V} & - \eta.\mathrm{cII}.\text{ſ}\mathrm{IV}.\text{ſ}\mathrm{V} \end{matrix}\right\}.$$

II) $$s\text{„}\mathrm{I}'\text{„}\mathrm{II}' = r.(-\text{ſ}\mathrm{I}.\mathrm{cII} - \eta.\text{ſ}\mathrm{I}.\text{ſ}\mathrm{II} + \varepsilon.\mathrm{cI}) = S\text{„}\overline{\mathrm{VI}}'\text{„}\overline{\mathrm{V}}'\text{„}\overline{\mathrm{IV}}'\text{„}\overline{\mathrm{III}}' =$$

$$r.\left\{\begin{matrix} \varepsilon.\mathrm{cIII}.\mathrm{cV} & - \eta.\text{ſ}\mathrm{IV}.\text{ſ}\mathrm{V} + \text{ſ}\mathrm{III}.\mathrm{cV} \\ - \varepsilon.\text{ſ}\mathrm{III}.\mathrm{cIV}.\text{ſ}\mathrm{V} & + \mathrm{cIII}.\mathrm{cIV}.\text{ſ}\mathrm{V} \end{matrix}\right\}.$$

III) $$s\text{„}\mathrm{I}'\text{„}\mathrm{II}'\text{„}\mathrm{III}' =$$

$$r.\left\{\begin{matrix} - \text{ſ}\mathrm{I}.\mathrm{cII}.\mathrm{cIII} & - \varepsilon.\text{ſ}\mathrm{I}.\mathrm{cII}.\text{ſ}\mathrm{III} & - \eta.\text{ſ}\mathrm{I}.\text{ſ}\mathrm{II} \\ - \mathrm{cI}.\text{ſ}\mathrm{III} & + \varepsilon.\mathrm{cI}.\mathrm{cIII} & \end{matrix}\right\} =$$

$$S\text{„}\overline{\mathrm{VI}}'\text{„}\overline{\mathrm{V}}'\text{„}\overline{\mathrm{IV}}' = r.(\varepsilon.\mathrm{cV} + \mathrm{cIV}.\text{ſ}\mathrm{V} - \eta.\text{ſ}\mathrm{IV}.\text{ſ}\mathrm{V}).$$

IV) $s\,,,\,\text{i}'\,,,\,\text{ii}'\,,,\,\text{iii}'\,,,\,\text{iv}' =$

$$r\,.\left\{\begin{array}{lll} \varepsilon\,.\,c\text{i}\,.\,c\text{iii} & -\,f\text{i}\,.\,c\text{ii}\,.\,c\text{iii}\,.\,c\text{iv} & -\,\eta\,.\,f\text{i}\,.\,f\text{ii}\,.\,c\text{iv} \\ -\,\varepsilon\,.\,f\text{i}\,.\,c\text{ii}\,.\,f\text{iii} & -\,c\text{i}\,.\,f\text{iii}\,.\,c\text{iv} & -\,\eta\,.\,f\text{i}\,.\,c\text{ii}\,.\,c\text{iii}\,.\,f\text{iv} \\ & +\,f\text{i}\,.\,f\text{ii}\,.\,f\text{iv} & -\,\eta\,.\,c\text{i}\,.\,f\text{iii}\,.\,f\text{iv} \end{array}\right\}$$

$= S\,,,\,\text{vi}'\,,,\,\text{v}' = r\,.\,(\varepsilon\,.\,c\text{v} + f\text{v}).$

IV.

Om sphæriske Polygoners Opløsning.

§ 36.

Et sphærisk Polygon er den Figur, som paa en Kugles Overflade (eller Yde) fremkommer ved at sammenfoie flere end to Storbuer saaledes, at den følgende begynder der, hvor den foregaaende slipper, og den sidste ophører hvor den første begynder. Polygonets Sider ere de Storbuer, hvoraf det er sammensat; Vinklernes Maal ere de Grader, som hver Sides Plan afviger fra Planet af foregaaende Sides Forlængning. Naar Radius er = 1, betegnes Polygonets Sider og Vinkler (Fig. 5) i den Orden, som de følge hinanden, ved i, ii, iii, iv, v, vi &c.; de uefne Tal bemærke Vinklerne, og de efne Siderne; ii er f. Ex. den Side mellem i og iii, iii den Vinkel, som Siden iv afviger fra Forlængningen af ii.

§ 37.

Dersom et Polygons Vinkler og Sider ere bekiendte, saa nær som een Vinkel og to Sider, eller saa nær som to Vinkler og een Side, eller tre Sider, eller tre Vinkler: da bestemmes det ubekiendte ved følgende Æqvation,

$$s\,,,\,\text{i}'\,,,\,\text{ii}'\,,,\,\text{iii}'\,,,\,\text{iv}'\,,,\,\text{v}'\,,,\,\text{vi}'\,,,\,\ldots\,,,\,\text{n}' = s,$$

i hvilken s er ubestemt, og kan antages enten for Horizontens og Verticalsirkelens fælles Radius r, eller s kan sættes $= \varepsilon r$, som er Kuglens horizontale Radius, der er perpendicular paa r, eller s kan sættes $= \eta r$, som er den verticale Radius, der er perpendicular paa r og paa εr. ε^2 ligesaavel som η^2 er $= -1$, i Følge § 27. $\mathrm{I}' = \cos.\mathrm{I} + \varepsilon \sin.\mathrm{I}$, $\mathrm{II}' = \cos.\mathrm{II} + \eta \sin.\mathrm{II}$, $\mathrm{III}' = \cos.\mathrm{III} + \varepsilon \sin \mathrm{III}$, ..., $\mathrm{N}' = \cos.\mathrm{N} + \eta \sin.\mathrm{N}$, $\bar{\mathrm{I}}' = \frac{1}{\cos.\mathrm{I} + \varepsilon \sin.\mathrm{I}}$, $\bar{\mathrm{II}}' = \frac{1}{\cos.\mathrm{II} + \eta \sin.\mathrm{II}}$ o. s. v. Teegnet (″), hvorved s, I′, II′ &c. ere forbundne, bemærker at s først skal multipliceres med I′, dernæst s ″ I′ med II′, saa s ″ I′ ″ II′ med III′, o. s. v.; men dog med den Indskrænkning, at den af de adderte Linier i Multiplicandum bliver uforandret, som ligger udenfor Planet af Cirkelbuen i Multiplicators Mærke, saa at η ″ $(\cos.\mathrm{I} + \varepsilon \sin.\mathrm{I}) = \eta$, ε ″ $(\cos.\mathrm{II} + \eta \sin.\mathrm{II}) = \varepsilon$, $(x + \eta y + \varepsilon z)$ ″ $(\cos.\mathrm{III} + \varepsilon \sin.\mathrm{III}) = \eta y + (x + \varepsilon z) . (\cos.\mathrm{III} + \varepsilon \sin.\mathrm{III})$, ligesom allerede tilforn er sagt § 28—32.

Hvordan omtalte Æqvation (s ″ I′ ″ II′ ″ III′ ″ IV′ . . . ″ N = s) kan tiene til et sphærisk Polygons Opløsning, indsees af følgende:

Lad Kuglen qhow (Fig. 6) kunne væltes om Axelen $\pi c n$ af den horizontale Storcirkel hpow, og om Axelen $pc\gamma$ af den verticale Storcirkel $q\pi o u$, uden at disse to Cirklers Position derved forandres, og lad samme Kugle

1) Stilles saaledes, at i Polygonet I II III IV V VI den sidste Sides sidste Punct falder i Horizontens Pol π, og samme Sides Forlængning falder i Verticalens Qvadrant πo Fig. 6.
2) Lad derpaa Kuglen væltes om Horizontens Axel $\pi c n$ de horizontale Grader I, saa falder Siden II i Veticalen mellem π og o, ligesom Fig. 7 forestiller.

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3) Naar nu Kuglen væltes om Verticalens Axel $p c \gamma$ de verticale Grader II, da gaaer hele Siden II igiennem Horizontens Pol π, og Kuglen faar Positionen Fig 8.

4) Væltes den nu atter om Horizontens Axel de horizontale Grader III, kommer derved Siden IV til at ligge i Verticalbuen mellem o og π (Fig. 9).

5) Og bliver man saaledes ved at omvælte Kuglen de verticale Grader IV, de horizontale V, de verticale VI &c.: faaer den tilsidst samme Position som den allerførst havde No. 1, Fig. 6.

I det at Kuglen omvæltes vexelviis paa Horizontens og Verticalcirkelens Axel, beskriver ethvert Kuglens Punct først en horizontal Bue, som er Maalet til Polygonets første Vinkel; dernæst en vertical Bue af saa mange Grader som Polygonets første Side; saa atter en horizontal, der maaler den anden Vinkel, o. s. f. lige til at Kuglen igien er kommeni første Position, og hvert dens Punct, efterat have beskrevet ligesaa mange horizontale Buer, som Polygonet har Vinkler, og ligesaa mange verticale, som det har Sider, er kommet tilbage til samme Sted, hvorfra det udgik.

6) Følgelig naar et Polygons Vinkler og Sider tilsammen ere af Antallet N, og i Kuglens første Position (Fig. 6) et af dens Puncter, hvilket som helst, havde til Coordinater de tre Linier, som udgiøre Summen $x + \eta y + \varepsilon z$ ($= s$): saa er i Følge § 33 $s = s$ „ I' „ II' „ III' „ IV' „ . . . „ N. Endnu maatte agtes

a) At paa Overfladen af Kuglen er, medens den omvæltedes, af det faste Punct p afridset et Polygon, hvori første Side er = Vinkelen I, følgende Vinkel = Siden II. følgende Side = Vinkelen III, o. s. v.; thi naar Kuglen væltes om Horiozntens Axel, og dens ydderste Dele stryge det faste Punct p forbi, tegner samme Punct paa Kuglens Overflade Polygonets Sider, og, naar den væltes om Verticalens Axel, faaer hver foregaaende Side sin Inclination til den følgendes Forlængning, hvilket just ikke er vanskeligt at forestille sig, skiøndt Polygonet har maattet udelades af Figurerne 6, 7 &c, for at ei den ene Linie skulde falde i den anden, og alt blive utydeligt.

b) Af det faste Punkt o er aftegnet et andet Polygon, hvis Vinkler ere deels — 90°, deels + 90°; Siderne ere I, II, III, IV, . . ., N, og Polygonets Æqvation er s „ I' „ (— ε) „ II' „ ε „ III' „ (— ε) „ IV' „ ε „ . . . . „ (— ε) „ N' „ ε = s. Dog herom maa være nok sagt, da denne Æqvation ei i det følgende er brugt. Jeg maa nu vende tilbage igien til den Formel, som jeg eengang har lagt til Grund for alle de øvrige, nemlig:

7) s „ I' „ II' „ III' „ IV' „ . . . „ N' = s. Denne Formel kan forandres paa mange Maader; thi da s er Summen af Coordinaterne til et bestemt Punct, saa kan isteden for s sættes hvad for en Linie det skal være, følgelig ogsaa ε, η, ηr eller εr.

8) I Formlens første Led kan af de Uniteter, som følge efter s, hvilken man vil antages for den første, naar den følgende tages for den anden, næstfølgende for den tredie, o. s. f., foregaaende for den sidste, næstforegaaende for næstsidste, o. s. v. Antages f. Ex. første Led at begynde med s „ III, da bliver Fig. 8 Kuglens første Position, Fig. 9 den anden, Fig. 7 den næstsidste, og Fig. 8 den sidste, saa at i Følge § 33,

og paa samme Maade, som før er viist, Æqvationen maa blive $s\,,,\,\text{III}'\,,,\,\text{IV}'\,,,\,\text{V}'\,,,\,\ldots\,,,\,\text{N}'\,,,\,\text{I}'\,,,\,\text{II}' = s$

9) De to nys omtalte Forandringer af Æqvationen $s\,,,\,\text{I}'\,,,\,\text{II}'\,,,\,\text{III}'\,,,\,\ldots\,,,\,\text{N}' = s$ have den Nytte, at hvilken man vil af Uniteterne $\text{I}', \text{II}', \text{III}', \ldots, \text{N}'$ kan elimineres; skal f. Ex. III' skaffes bort, da forandrer jeg Æqvationen til $s\,,,\,\text{III}'\,,,\,\text{IV}'\,,,\,\text{V}'\,,,\,\ldots\,,,\,\text{N}'\,,,\,\text{I}'\,,,\,\text{II}' = s$, derefter sætter jeg $s = \eta r$, hvorved $s\,,,\,\text{III}'$ bliver $= \eta r$ efter § 28. Skal IV' udelades, forandres Æqvationen til $s\,,,\,\text{IV}'\,,,\,\text{V}'\,,,\,\ldots\,,,\,\text{N}'\,,,\,\text{I}'\,,,\,\text{II}'\,,,\,\text{III}' = s$, og s sættes $= \varepsilon r$, hvorved $s\,,,\,\text{IV}'$ bliver efter § 29 saa stor som εr.

10) Da $s\,,,\,\text{I}'\,,,\,\text{II}'\,,,\,\ldots\,,,\,\text{N}' = s$, saa er i Følge § 33 $s\,,,\,\overline{\text{N}}'\,,,\,\ldots\,,,\,\overline{\text{VI}}'\,,,\,\overline{\text{V}}' = s\,,,\,\text{I}'\,,,\,\text{II}'\,,,\,\text{III}'\,,,\,\text{IV}'$, eller man kan i Almindelighed borttage af Æqvationens første Led saa mange som man vil af de sidste Uniteter, naar alene de borttagnes reciproqve Størrelser i omvendt Orden sammenføies indbyrdes ved Tegnet ("), og derefter ved samme Tegn " forbindes med det andet Led s.

11) Herved kan i et af Æqvationens Led hvilken Unitet, som forlanges blive den sidste, og følgelig en Ligning udbringes, hvori denne Unitet ei findes. Naar f. Ex. i Æqvationen $s\,,,\,\text{I}'\,,,\,\text{II}'\,,,\,\text{III}'\,,,\,\text{IV}' = s\,,,\,\overline{\text{N}}'\,,,\,\ldots\,,,\,\overline{\text{VI}}'\,,,\,\overline{\text{V}}'$ hele det første Led er $= x + \eta y + \varepsilon z$, men det andet Led er $= \mathfrak{x} + \eta\mathfrak{y} + \varepsilon\mathfrak{z}$: da er i Følge § 3 $\varepsilon z = \varepsilon\mathfrak{z}$, i hvilken Ligning ei findes IV'; thi $\text{IV}' = \cos.\,\text{IV} + \eta \sin.\,\text{IV}$, altsaa, da der multiplicertes i første Led med IV', blev εz uforandret, § 29.

12) Den Æqvation, som man finder for den søgte ubekiendte u, efterat have paa anførte Maade elimineret de to andre ubekiendte, som ikke søges, har den Form: $a = b\cos.\,u + c\sin.\,u$; thi man seer let, at den aldrig

kan indeholde cos. u . sin. u, eller Potenzer af cos. u og sin. u. For at opløse denne Æqvation, kan sættes, ligesom tilforn er viist (§ 20), $\frac{b}{c} = \cot. \psi$, og $\cos. (u - \psi) = \frac{a \sin. \psi}{c} = \frac{a \cos. \psi}{b}$.

13) Er Kuglens Radius r uendelig stor, og det sphæriske Polygons Sider uendelig smaa Dele af Peripherien, da forvandles det sphæriske til et plant Polygon, hvis Sider ere Sinus af Siderne i det sphæriske multiplicerte med Kuglens Radius. Opløsningen passer altsaa baade til sphæriske og plane Polygoner.

V.

Nu vil jeg forsøge at udlede af samme Æqvation (§ 37 No. 6)

de sphæriske Trianglers fornemste Egenskaber.

§ 38.

Da Triangelens Æqvation er s „ I' „ II' „ . . . „ VI' = s (§ 37 No. 6), og Progressionens Begyndelse er ubestemt (§ 37 No. 8): saa kan den begynde med I' eller III' eller V', hvis dernemlig antages at første Unitet skal ligge i Horizontens Plan, eller at den skal være cos. + ε sin. Jeg betegner derfor de Linier i Progressionen, som følge efter VI', ved VII', VIII', IX', X', XI' &c., saa at I', VII' XIII' blive Synonyma, ligesaavel som II', VIII', XIV' o. s. v. Denne Maade at tælle paa kan ikke forvilde; thi hvilken i Ordenen Linien er, naar ei tælles længere end til VI. findes ved at subtrahere VI saa ofte som mueligt fra de dette Tal overstigende Nummere. Denæst sætter jeg den Vinkels cos. +

ε sin., hvoraf Progressionen begynder, at være $(n+\mathrm{I})'$, og lader n være ubestemt, uden for saavidt at den enten betegner 0, eller et effent Tal. Triangelens almindeligere Æqvation bliver derfor i Følge denne Benævning og § 37 No 8:

$$s \text{ „ } (n+\mathrm{I})' \text{ „ } (n+\mathrm{II})' \text{ „ } (n+\mathrm{III})' \text{ „ } (n+\mathrm{IV})' \text{ „ } (n+\mathrm{V})' \text{ „ } (n+\mathrm{VI})' = s.$$

Forandres denne Æqvation i Overensstemmelse med § 33 til

$$\varepsilon \text{ „ } (n+\mathrm{I})' \text{ „ } (n+\mathrm{II})' = \varepsilon \text{ „ } (n+\mathrm{VI})^{-\prime} \text{ „ } (n+\mathrm{V})^{-\prime} \text{ „ } (n+\mathrm{IV})^{-\prime} \text{ „ } (n+\mathrm{III})^{-\prime}:$$

findes, i Følge § 35 No. *II*, og § 3,

I) $\cos.(n+\mathrm{I}) = \cos.(n+\mathrm{III}).\cos.(n+\mathrm{V}) - \sin.(n+\mathrm{III}).\cos.(n+\mathrm{IV}).\sin.(n+\mathrm{V}).$

II) $\sin.(n+\mathrm{I}) = \dfrac{\sin.(n+\mathrm{IV}).\sin.(n+\mathrm{V})}{\sin.(n+\mathrm{II})}.$

Forandres den til $\varepsilon \text{ „ } (n+\mathrm{I})' \text{ „ } (n+\mathrm{II})' \text{ „ } (n+\mathrm{III})' \text{ „ } (n+\mathrm{IV})' = \varepsilon \text{ „ } (n+\mathrm{VI})^{-\prime} \text{ „ } (n+\mathrm{V})^{-\prime}$, udkommer en Æqvation liig den § 35, No. *IV*, alene at n er tilføiet Tallene I, II, III &c., og r antaget $=$ I. Altsaa, naar denne Æqvations Led, der indeholde η, divideres med sin. $(n+\mathrm{I})$, bliver:

III) $-\cot.(n+\mathrm{I}) = \dfrac{\cot.(n+\mathrm{IV}).\sin.(n+\mathrm{II})}{\sin.(n+\mathrm{III})} + \cot.(n+\mathrm{III}).\cos.(n+\mathrm{II}).$

Forandres den til $\eta \text{ „ } (n+\mathrm{I})' \text{ „ } (n+\mathrm{II})' \text{ „ } (n+\mathrm{III})' = \eta \text{ „ } (n+\mathrm{VI})^{-\prime} \text{ „ } (n+\mathrm{V})^{-\prime} \text{ „ } (n+\mathrm{IV})^{-\prime}$, giver den i Følge § 34 No. *II*.

IV) $\cos.(n+\mathrm{II}) = \cos.(n+\mathrm{IV}).\cos.(n+\mathrm{VI}) - \sin(n+\mathrm{IV}).\cos.(n+\mathrm{V}).\sin.(n+\mathrm{VI})$

V) $\sin.(n+\mathrm{II}) = \dfrac{\sin.(n+\mathrm{V}).\sin.(n+\mathrm{VI})}{\sin.(n+\mathrm{III})}.$

Og endelig naar den forandres til η „ (n + I)' „ (n + II)' „ (n + III)' „ (n + IV)' „ (n + V)' = η „ (n + VI)', faaes af det Led, som indeholder ε, § 34, No. *IV*,

$$VI)\ -\cot.(n+II)=\frac{\cot(n+V).\sin.(n+III)}{\sin.(n+IV)}+\cot.(n+IV).\cos.(n+III).$$

§ 39.

I de foregaaende sex Æqvationer forudsættes, n at betegne Nul, eller ethvert positiv effent Tal; men ved at sammenligne de tre første med de tre sidste, vil man finde, at i de første tre kan ogsaa isteden for n sættes n + I, eller ethvert ueffent positivt Tal; altsaa kan i de tre første Æqvationer n bemærke Nul, eller ethvert positiv heelt Tal. Der kan ogsaa isteden for n sættes n + et positiv heelt Tal, hvilket som helst; man kan f. Ex. sætte isteden for n: 0 + 3, 1 + 3, 2 + 3, 3 + 3, og saa videre, altsaa n + 3. Hvoraf følger: at, naar i Æqvationen *III*, § 38 isteden for n sættes n + III, forvandles den til

$$-\cot.(n+IV)=\frac{\cot.(n+VII).\sin.(n+V)}{\sin.(n+VI)}+\cot.(n+VI).\cos.(n+V).$$

Følgelig er

$$-\cot.(n+I)=\frac{\cot.(n+IV).\sin.(n+VI)}{\sin.(n+V)}+\cot.(n+V).\cos.(n+VI),$$

og denne Æqvation sammenlignet, med Æqvationen *III*, § 38, giver følgende dobbelte Udtryk af — cot. (n + I).

$$I)\ -\cot.(n+I)=\frac{\cot.(n+IV).\sin.\binom{n+II}{n+VI}}{\sin.\binom{n+III}{n+V}}+\cot.\binom{n+III}{n+V}.\cos.\binom{n+II}{n+VI}.$$

efter hvilken Formel $-\cot.(n+\text{I})$ faar samme Værdie, enten man bruger kun de øverste, eller kun de nederste af de dobbelte Tal.

Ligeledes naar i Æqvationen *II*, § 38 sættes $n+\text{II}$ isteden for n, udkommer:

$$\sin.(n+\text{III}) = \frac{\sin.(n+\text{VI}).\sin.(n+\text{I})}{\sin.(n+\text{IV})}, \text{ altsaa}$$

$$\sin.(n+\text{I}) = \frac{\sin.(n+\text{III}).\sin.(n+\text{IV})}{\sin.(n+\text{VI})},$$

af hvilken Æqvation og den § 38 No. *II* følger:

$$II)\ \sin.(n+\text{I}) = \frac{\sin.(n+\text{IV}).\sin.\binom{n+\text{III}}{n+\text{V}}}{\sin.\binom{n+\text{VI}}{n+\text{II}}}.$$

Sættes der i Æqvationen *I*, § 38 Tallet $n+\text{III}$ isteden for n, faaes:

$$III)\ \cos.(n+\text{I}) = \frac{\cos.(n+\text{VI}).\cos.(n+\text{II}) - \cos.(n+\text{IV})}{\sin.(n+\text{VI}).\sin.(n+\text{II})}.$$

§ 40.

Ved samme Substitution faaes af samme Æqvation

$$\cos(n+\text{IV}) = \cos.(n+\text{VI})\cos.(n+\text{II}) = \sin.(n+\text{VI}).\cos.(n+\text{I}).\sin.(n+\text{II}),$$

eller

$$-\cos.(n+\text{IV}) + \frac{\cos.(n+\text{VI}).\cos.(n+\text{II})}{\sin.(n+\text{IV})}.\sin.(n+\text{IV}) = \sin.(n+\text{VI}).\sin.(n+\text{II}).\cos.(n+\text{I}).$$

Altsaa, naar denne Æqvations sidste Led kaldes a, $\cos.(n+\text{IV})$ sættes $= \cos.u$, $-\text{I} = b$, og

$\frac{\cos.(n+\text{VI}).\cos.(n+\text{II})}{\sin.(n+\text{IV})} = c$: kan i Følge § 20 antages

$$\text{tang.}\,\psi = -\frac{\cos.(n+\text{VI}).\cos.(n+\text{II})}{\sin.(n+\text{IV})},\ \text{og}$$

$$\cos.(n+\text{I}) = -\frac{\cos.[(n+\text{IV})-\psi]}{\cos.\psi.\sin.(n+\text{VI}).\sin.(n+\text{II})}.$$

§ 41.

Æqvationen *I* § 38 er

$$\overbrace{\underbrace{\cos.(n+\text{I})}_{a}}^{a} = \underbrace{\cos.\overbrace{(n+\text{III})}^{u}}_{b}\,.\,\overbrace{\cos.\underbrace{(n+\text{V})}_{u}}^{b}$$

$$-\underbrace{\sin.\overbrace{(n+\text{III})}^{u}.\overbrace{\cos.(n+\text{IV})}_{c}}\!\!\!\!^{c}\ .\ \sin.\underbrace{(n+\text{V})}_{u},$$

og naar dennes Termini benævnes ved de under eller over skrevne Bogstaver a, b, c, u: da findes, i Følge § 20, cos. (n + I) ved følgende formler:

$$-\cos.(n+\text{IV}).\text{tang.}\binom{n+\text{V}}{n+\text{III}} = \cot.\binom{\varphi'}{\varphi},\ \text{og}$$

$$\cos.(n+\text{I}) = \frac{\sin.\binom{(n+\text{III})+\varphi'}{(n+\text{V})+\varphi}.\cos.\binom{n+\text{V}}{n+\text{III}}}{\sin.\binom{\varphi'}{\varphi}}.$$

§ 42.

I Følge § 39 No. *I* er

$$-\cot.(n+\text{I}) = \frac{\cot.(n+\text{IV}).\sin.\binom{n+\text{VI}}{n+\text{II}}}{\sin.\binom{n+\text{V}}{n+\text{III}}} +$$

$$\cot.\binom{n+\text{V}}{n+\text{III}}.\cos.\binom{n+\text{VI}}{n+\text{II}},$$

og naar — cot. (n + I) = a, $\frac{\text{cot. (n + IV)}}{\text{sin.}\binom{\text{n + V}}{\text{n + III}}}$ = c, $\binom{\text{n + VI}}{\text{n + II}}$ = u,

$$\text{cot.}\binom{\text{n + V}}{\text{n + III}} = \text{b},$$

og Æqvationen sammenlignes med den § 20, da vil let indsees Rigtigheden af følgende Formler:

$$\text{tang.}\binom{\varphi'}{\varphi} = \text{tang. (n + IV) . cos.}\binom{\text{n + V}}{\text{n + III}}.$$

$$-\text{cot. (n + I)} = \frac{\text{sin.}\binom{\text{(n + VI)} + \varphi'}{\text{(n + II)} + \varphi}}{\text{sin.}\binom{\varphi'}{\varphi}} \text{. cot.}\binom{\text{n + V}}{\text{n + III}}.$$

§ 43.

Sættes der i de to sidste Æqvationer § 41 n + II isteden for n: bliver

$$\text{cot.}\ \varphi = -\text{cos. (n + VI) . tang. (n + V), og}$$

$$\text{sin. ((n + I)} + \varphi) = \frac{\text{cos. (n + III) . sin.}\ \varphi}{\text{cos. (n + V)}}.$$

Men sættes n + IV isteden for n, bliver

$$\text{cot.}\ \varphi' = -\text{cos. (n + II) . tang. (n + III) og}$$

$$\text{sin. ((n + I)} + \varphi') = \frac{\text{cos. (n + V) . sin.}\ \varphi'}{\text{(cos. n + III)}}.$$

Altsaa

$$\text{sin.}\binom{\text{(n + I)} + \varphi'}{\text{(n + I)} + \varphi} = \frac{\text{cos.}\binom{\text{(n + V)}}{\text{(n + III)}}}{\text{cos.}\binom{\text{(n + III)}}{\text{(n + V)}}} \text{. sin.}\binom{\varphi'}{\varphi}\text{, og}$$

$$\text{cot.}\binom{\varphi'}{\varphi} = -\text{cos.}\binom{\text{n + II}}{\text{n + VI}} \text{. tang.}\binom{\text{n + III}}{\text{n + V}}$$

§ 44.

Ved at sætte n + v isteden for n i de to sidste Æqvationer § 42, faaes

$$\sin.[(n+\text{I})+\varphi] = -\cot.(n+\text{VI}).\tang(n+\text{II}).\sin.\varphi, \text{ og}$$
$$\tang.\varphi = \tang.(n+\text{III}).\cos.(n+\text{II});$$

Men ved at sætte n + I isteden for n, udkommer:

$$\sin.[(n+\text{I})+\varphi'] = -\cot.(n+\text{II}).\tang.(n+\text{VI}).\sin.\varphi', \text{ og}$$
$$\tang.\varphi' = \tang.(n+\text{V}).\cos.(n+\text{VI});$$

hvoraf følger:

$$\sin.\left(\frac{(n+\text{I})+\varphi'}{(n+\text{I})+\varphi}\right) = -\cot.\left(\frac{n+\text{II}}{n+\text{VI}}\right).\tang.\left(\frac{n+\text{VI}}{n+\text{II}}\right).\sin.\left(\frac{\varphi'}{\varphi}\right), \text{ og}$$

$$\tang.\left(\frac{\varphi'}{\varphi}\right) = \tang.\left(\frac{n+\text{V}}{n+\text{III}}\right).\cos.\left(\frac{n+\text{VI}}{n+\text{II}}\right).$$

§ 45.

$$\text{Sin.}^2\tfrac{1}{2}(n+\text{I}) = \frac{\sin.\tfrac{1}{2}[(n+\text{II})+(n+\text{IV})+(n+\text{VI})].\sin.\tfrac{1}{2}[(n+\text{II})+(n+\text{VI})-(n+\text{IV})]}{\sin.(n+\text{II}).\sin.(n+\text{VI})};$$

thi $\cos.(n+\text{I}) = \dfrac{\cos.(n+\text{VI}).\cos.(n+\text{II})-\cos.(n+\text{IV})}{\sin.(n+\text{VI}).\sin.(n+\text{II})}$, § 39 No *III*,

og $2\sin.^2\tfrac{1}{2}(n+\text{I}) = 1-\cos.(n+\text{I})$, § 19 *e*. Altsaa

$$2\sin.^2\tfrac{1}{2}(n+\text{I}) = 1 - \frac{\cos(n+\text{VI}).\cos(n+\text{II})-\cos.(n+\text{IV})}{\sin.(n+\text{VI}).\sin.(n+\text{II})}, \text{ eller}$$

$$2\sin.^2\tfrac{1}{2}(n+\text{I}) = \frac{\sin.(n+\text{VI}).\sin.(n+\text{II})-\cos.(n+\text{VI}).\cos.(n+\text{II})+\cos.(n+\text{IV})}{\sin.(n+\text{VI}).\sin.(n+\text{II})},$$

eller, i Følge § 19 *b*,

$$2\sin.^2\tfrac{1}{2}(n+\mathrm{I}) = \frac{\cos.(n+\mathrm{IV}) - \cos.[(n+\mathrm{VI})+(n+\mathrm{II})]}{\sin.(n+\mathrm{VI}).\sin.(n+\mathrm{II})},$$

og da $\cos.b - \cos.a = 2\sin.\tfrac{1}{2}(a+b).\sin.\tfrac{1}{2}(a-b)$, § 19 *i*: saa bliver

$$\sin.^2\tfrac{1}{2}(n+\mathrm{I}) = \frac{\sin.\tfrac{1}{2}[(n+\mathrm{IV})+(n+\mathrm{VI})+(n+\mathrm{II})].\sin.\tfrac{1}{2}[(n+\mathrm{VI})+(n+\mathrm{II})-(n+\mathrm{IV})]}{\sin.(n+\mathrm{VI}).\sin.(n+\mathrm{II})}.$$

§ 46.

$$\mathrm{Cos}.^2\tfrac{1}{2}(n+\mathrm{I}) = \frac{\sin.\tfrac{1}{2}[(n+\mathrm{IV})+(n+\mathrm{II})-(n+\mathrm{VI})].\sin.\tfrac{1}{2}[(n+\mathrm{IV})-(n+\mathrm{II})+(n+\mathrm{IV})]}{\sin.(n+\mathrm{II}).\sin.(n+\mathrm{VI})};$$

thi $1+\cos.(n+\mathrm{I}) = 2\cos.^2\tfrac{1}{2}(n+\mathrm{I})$, § 19 *d*; men efter Æqvationen *III* § 39 er

$$1+\cos.(n+\mathrm{I}) = \frac{\sin.(n+\mathrm{II}).\sin.(n+\mathrm{VI}) + \cos(n+\mathrm{II}).\cos.(n+\mathrm{VI}) - \cos.(n+\mathrm{VI})}{\sin.(n+\mathrm{II}).\sin.(n+\mathrm{VI})},$$

altsaa

$$2\cos.^2\tfrac{1}{2}(n+\mathrm{I}) = \frac{\cos.[(n+\mathrm{II})-(n+\mathrm{VI})] - \cos.(n+\mathrm{IV})}{\sin.(n+\mathrm{II}).\sin.(n+\mathrm{VI})},\ \text{§ 19 } b.$$

Følgelig, da $\cos.b - \cos.a = 2\sin.\tfrac{1}{2}(a+b).\sin.\tfrac{1}{2}(a-b)$ § 19 *i*, saa er

$$\cos.^2\tfrac{1}{2}(n+\mathrm{I}) = \frac{\sin.\tfrac{1}{2}[(n+\mathrm{II})+(n+\mathrm{IV})-(n+\mathrm{VI})].\sin.\tfrac{1}{2}[(n+\mathrm{IV})-(n+\mathrm{II})+(n+\mathrm{VI})]}{\sin.(n+\mathrm{II}).\sin.(n+\mathrm{VI})}.$$

§ 47.

$$-\mathrm{tang}.\tfrac{1}{2}[(n+\mathrm{I})-(n+\mathrm{III})] = \frac{\sin.\tfrac{1}{2}[(n+\mathrm{IV})-(n+\mathrm{IV})]}{\sin.\tfrac{1}{2}[(n+\mathrm{IV})+(n=\mathrm{VI})]}$$

$\mathrm{tang}.\tfrac{1}{2}(n+\mathrm{V})$, og

$$-\text{tang.}\,\tfrac{1}{2}[(n+\text{I})+(n+\text{III})]=\frac{\cos\,\tfrac{1}{2}[(n+\text{IV})-(n+\text{VI})]}{\cos\,\tfrac{1}{2}[(n+\text{IV})+(n+\text{VI})]}\cdot\text{tang.}\,\tfrac{1}{2}(n+\text{V}),$$

hvilket kan bevises saaledes:

I) Ved at addere og subtrahere sin. (n + I), forandres Æqvationen

$$\sin.(n+\text{III})=\frac{\sin.(n+\text{I})\,.\,\sin.(n+\text{VI})}{\sin.(n+\text{IV})},\ \S\ 39\ \mathit{II},$$

til de to følgende

a) $\sin.(n+\text{I})-\sin.(n+\text{III})=$

$$\frac{\sin.(n+\text{I})\,.\,\sin.(n+\text{IV})-\sin.(n+\text{I})\,.\,\sin.(n+\text{VI})}{\sin\,(n+\text{IV})},\ \text{og}$$

b) $\sin.(n+\text{I})+\sin.(n+\text{III})=$

$$\frac{\sin(n+\text{I})\,.\,\sin.(n+\text{IV})+\sin.(n+\text{I})\,.\,\sin.(n+\text{IV})}{\sin.(n+\text{IV})}.$$

Af Æqvationen *I*, § 39 udkommer, ved at sætte n + II isteden for n, Æqvationen

$$-\cot.(n+\text{III})=\frac{\cos.(n+\text{IV})\cos.(n+\text{V})}{\sin.(n+\text{V})}+$$

$$+\frac{\sin.(n+\text{IV})\,.\,\cos.(n+\text{VI})}{\sin.(n+\text{V})\,.\,\sin.(n+\text{VI})}.$$

Naar dennes Led multipliceres med Ledene i Æqvationen

$$\sin.(n+\text{III})=\frac{\sin.(n+\text{I})\,.\,\sin.(n+\text{VI})}{\sin.(n+\text{IV})},\ \S\ 39\ \mathit{II},\ \text{bliver}$$

$$-\cos(n+\text{III})=\frac{\cos(n+\text{IV})\,.\,\sin(n+\text{VI})\,.\,\sin(n+\text{I})\,.\,\cos(n+\text{V})}{\sin.(n+\text{IV})\,.\,\sin.(n+\text{V})}+$$

$$\frac{\cos\,(n+\text{VI})\,.\,\sin.(n+\text{I})}{\sin.(n+\text{V})};$$

men da

$$-\cos.(n+\text{I}) = \frac{\cos.(n+\text{VI}).\cos.(n+\text{V}).\sin.(n+\text{I})}{\sin.(n+\text{V})} +$$

$$\frac{\sin.(n+\text{VI})\ \cos.(n+\text{IV}).\sin.(n+\text{I})}{\sin.(n+\text{IV}).\sin.(n+\text{V})}, \text{ § 39 } I:$$

saa er Summen

$$c)\ -\cos.(n+\text{I}) - \cos.(n+\text{III}) =$$

$$\frac{[\cos.(n+\text{V})+1].\sin.[(n+\text{IV})+(n+\text{VI})]}{\sin.(n+\text{IV})} \cdot \frac{\sin(n+\text{I})}{\sin.(n+\text{V})},$$

og naar divideres Formelen *a* med Formelen *c*, faaes:

$$-\frac{\sin.(n+\text{I}) - \sin.(n+\text{III})}{\cos.(n+\text{I}) + \cos.(n+\text{III})} =$$

$$\frac{\sin.(n+\text{V})}{1+\cos.(n+\text{V})} \cdot \frac{\sin.(n+\text{IV}) - \sin.(n+\text{VI})}{\sin.[(n+\text{IV})+(n+\text{VI})]};$$

men $\frac{\sin.(n+\text{I}) - \sin.(n+\text{III})}{\cos.(n+\text{I}) + \cos.(n+\text{III})} =$

$$\text{tang.}\tfrac{1}{2}[(n+\text{I}) - (n+\text{III})], \text{ § 19 } l,$$

og $\frac{\sin.(n+\text{V})}{1+\cos.(n+\text{V})} = \text{tang.}\ \frac{1}{2}(n+\text{V})$, § 19 *f*.

Altsaa $-\text{tang.}\frac{1}{2}[(n+\text{I}) - (n+\text{III})] =$

$$\frac{\text{tang.}\tfrac{1}{2}(n+\text{V}).[\sin.(n+\text{IV}) - \sin.(n+\text{VI})]}{\sin.[(n+\text{IV})+(n+\text{VI})]},$$

og da $\sin.(n+\text{IV}) - \sin.(n+\text{VI}) =$

$$2\cos\tfrac{1}{2}[(n+\text{IV})+(n+\text{VI})] \rtimes \sin\tfrac{1}{2}[(n+\text{IV})-(n+\text{VI})], \text{ § 19 } h,$$

og $\frac{2\cos.\frac{1}{2}[n+\text{IV})+(n+\text{VI})]}{\sin.[(n+\text{IV})+(n+\text{VI})]} =$

$$\frac{1}{\sin.\tfrac{1}{2}[(n+\text{IV})+(n+\text{VI})]}, \text{ § 19 } c:$$

saa er $-\text{tang.}\,\frac{1}{2}[(n+\text{I})-(n+\text{III})]=$

$$\frac{\text{tang.}\,\frac{1}{2}(n+\text{V})\,.\,\sin\,\frac{1}{2}[(n+\text{IV})-(n+\text{VI})]}{\sin.\,\frac{1}{2}[(n+\text{IV})+(n+\text{VI})]}.$$

II) Ligeledes findes ved at dividere Formlen b med Formlen c:

$$-\frac{\sin.\,(n+\text{I})+\sin\,(n+\text{III})}{\cos.\,(n+\text{I})+\cos.\,(n+\text{III})}=$$

$$\frac{\sin.\,(n+\text{V})}{1+\cos.\,(n+\text{V})}\cdot\frac{\sin.\,(n+\text{IV})+\sin.\,(n+\text{VI})}{\sin\,[(n+\text{IV})+(n+\text{VI})]}=$$

$-\text{tang}\,\frac{1}{2}[(n+\text{I})+(n+\text{III})]$, § 19 k,

og naar isteden for $\frac{\sin.\,(n+\text{V})}{1+\cos.\,(n+\text{V})}$ sættes $\text{tang.}\,\frac{1}{2}(n+\text{V})$,

§ 19 f, og isteden for $\sin.\,(n+\text{IV})+\sin.\,(n+\text{VI})$ sættes

$2\sin.\,\frac{1}{2}[(n+\text{IV})+(n+\text{VI})]\,.\,\cos.\,\frac{1}{2}[(n+\text{IV})-(n+\text{VI})]$,

§ 19 g, udkommer

$$\text{tang.}\,\frac{1}{2}(n+\text{V})\,.\,\frac{2\sin.\,\frac{1}{2}[(n+\text{IV})+(n+\text{VI})]\,.\,\cos.\,\frac{1}{2}[(n+\text{IV})-(n+\text{VI})]}{\sin.\,[(n+\text{IV})+(n+\text{VI})]}=$$

$-\text{tang.}\,\frac{1}{2}[(n+\text{I})+(n+\text{III})]$;

men da $\frac{2\sin.\,\frac{1}{2}[(n+\text{IV})+(n+\text{VI})]}{\sin.\,[(n+\text{IV})+(n+\text{VI})]}=$

$\frac{1}{\cos.\,\frac{1}{2}[(n+\text{IV})+(n+\text{VI})]}$, i Følge § 19 c:

saa er $-\text{tang.}\,\frac{1}{2}[(n+\text{I})+(n+\text{III})=$

$$\text{tang.}\,\frac{1}{2}(n+\text{V})\,.\,\frac{\cos.\,\frac{1}{2}[(n+\text{IV})-(n+\text{VI})]}{\cos.\,\frac{1}{2}[(n+\text{IV})+(n+\text{VI})]}.$$

§ 48.

Ere alle tre Vinkler i en sphærisk Triangel givne, findes Siderne ved hvilken man vil af følgende Formler, naar n antages = 0, II, eller IV.

$$I)\ \cos.(n+\text{II}) = \frac{\cos.(n+\text{I}).\cos.(n+\text{III}) - \cos.(n+\text{V})}{\sin.(n+\text{I}).\sin.(n+\text{III})},$$

§ 39 Æqv. *III.*

$$II) \left\{ \begin{array}{l} \cos.(n+\text{II}) = -\dfrac{\cos.[n+\text{V}) - \psi]}{\cos.\psi.\sin.(n+\text{I}).\sin(n+\text{III})}, \text{ og} \\ \operatorname{tang}.\psi = -\dfrac{\cos.(n+\text{I}).\cos.(n+\text{III})}{\sin.(n+\text{V})}. \end{array} \right\} \S\ 40.$$

$$III)\ \sin.^2 \tfrac{1}{2}(n+\text{II}) =$$

$$\frac{\sin\frac{1}{2}[(n+\text{III})+(n+\text{V})+(n+\text{I})].\sin\frac{1}{2}[(n+\text{III})+(n+\text{I})-(n+\text{V})]}{\sin.(n+\text{III}).\sin.(n+\text{I})},$$

§ 45.

Sættes i den første af disse tre Formler

a) $n+\text{I} = 90°$, bliver $\cos.(n+\text{II}) =$
$- \cos.(n+\text{V}):\sin.(n+\text{III})$.

b) $n+\text{III} = 90°$, bliver $\cos.(n+\text{II}) =$
$- \cos.(n+\text{V}):\sin.(n+\text{I})$.

c) $n+\text{V} = 90°$, bliver $\cos.(n+\text{II}) =$
$\cot.(n+\text{I}).\cot.(n+\text{III})$.

§ 49

Af to Vinkler og deres fælles Side givne bestemmes

A) Den givne Sides modstaaende Vinkel med Formlen *IV*, eller *V*, naar sættes n = 0, eller II, eller IV.

$$IV) \cos(n+1) = \frac{\cos(n+\text{III}).\cos(n+\text{V}) - \sin(n+\text{III}).\cos(n+\text{IV})}{\sin.(n+\text{V})}.$$

§ 38 Æqvationen *I.*

$$V)\left\{\begin{aligned}&\cos.(n+I)=\frac{\sin.\begin{pmatrix}(n+III)+\Phi'\\(n+V)+\Phi\end{pmatrix}.\cos.\begin{pmatrix}n+V\\n+III\end{pmatrix}}{\sin.\begin{pmatrix}\Phi'\\\Phi\end{pmatrix}},\text{ og}\\&\cot.\begin{pmatrix}\varphi'\\\varphi\end{pmatrix}=-\cos.(n+IV).\tan g.\begin{pmatrix}n+V\\n+III\end{pmatrix}.\end{aligned}\right\}\ \S\ 41.$$

1 Æqvationen *IV* giver

a) $n+III=90°$: $\cos(n+I)=$
$-\cos.(n+IV).\sin.(n+V)$.

b) $n+V=90°$: $\cos.(n+I)=$
$-\cos.(n+IV).\sin.(n+III)$.

c) $n+VI=90°$: $\cos.(n+I)=$
$\cos.(n+III).\cos.(n+V)$,

B) De to andre Sider findes ved hvilken som helst af følgende Formler, hvori ligeledes maa antages $n=0$ eller II, eller IV.

$$VI)\ -\cot.(n+II)=\frac{\cot.(n+V).\sin.\begin{pmatrix}n+III\\n+I\end{pmatrix}}{\sin.\begin{pmatrix}n+IV\\n+VI\end{pmatrix}}+$$

$$\cot.\begin{pmatrix}n+IV\\n+VI\end{pmatrix}.\cos.\begin{pmatrix}n+III\\n+I\end{pmatrix},\ \S\ 39,\ \text{Æqv. 1.}$$

$$VII)\left\{\begin{aligned}&-\cot.(n+II)=\frac{\sin.\begin{pmatrix}(n+I)+\Phi'\\(n+III)+\Phi\end{pmatrix}}{\sin\begin{pmatrix}\varphi'\\\varphi\end{pmatrix}}.\cot.\begin{pmatrix}n+VI\\n+IV\end{pmatrix},\text{ og}\\&\tan g\begin{pmatrix}\varphi'\\\varphi\end{pmatrix}=\tan g.(n+V).\cos.\begin{pmatrix}n+VI\\n+IV\end{pmatrix}.\end{aligned}\right\}\ \S\ 42.$$

Trykt den 29. Mai 1896.

$$VIII)\left\{\begin{array}{l} -\text{tang.}\tfrac{1}{2}[(n+\text{II})-(n+\text{IV})]= \\ \qquad\qquad \text{tang.}\tfrac{1}{2}[(n+\text{VI})\,.\,\dfrac{\sin.\frac{1}{2}[(n+\text{V})-(n+\text{I})]}{\sin.\frac{1}{2}[(n+\text{V})+(n+\text{I})]}. \\ -\text{tang.}\tfrac{1}{2}[(n+\text{II})+(n+\text{IV})]= \\ \qquad\qquad \text{tang.}\tfrac{1}{2}(n+\text{VI})\,.\,\dfrac{\cos.\frac{1}{2}[(n+\text{V})-(n+\text{I})]}{\cos.\frac{1}{2}[(n+\text{V})+(n+\text{I})]}. \end{array}\right\}\S\,47.$$

Er i den *VI*te Formel

d) $n+\text{III}=90°$, bliver $-\cot.(n+\text{II})=$
$\cot.(n+\text{V}):\sin.(n+\text{IV})$.

e) $n+\text{IV}=90°$, bliver $-\cot.(n+\text{II})=$
$\cot.(n+\text{V})\,.\,\sin.(n+\text{III})$.

f) $n+\text{V}=90°$, bliver $-\cot.(n+\text{II})=$
$\cot.\binom{n+\text{VI}}{n+\text{IV}}\,.\,\cos.\binom{n+\text{I}}{n+\text{III}}$.

g) $n+\text{I}=90°$, bliver $-\cot.(n+\text{II})=$
$\cot.(n+\text{V}):\sin.(n+\text{VI})$.

h) $n+\text{VI}=90°$, bliver $-\cot.(n+\text{II})=$
$\cot.(n+\text{V})\,.\,\sin.(n+\text{I})$.

§ 50.

Af een Vinkel og to Sider, hvoraf den ene staaer lige over for den givne Vinkel, findes

A) Den tredie Side ved følgende *IX*de Formel, naar sættes $n=0$, II, eller IV.

$$IX)\left\{\begin{array}{l} \sin.\begin{pmatrix}(n+\text{II})+\varphi'\\(n+\text{II})+\varphi\end{pmatrix}=\dfrac{\cos.\binom{n+\text{VI}}{n+\text{IV}}\,.\,\sin.\binom{\Phi'}{\Phi}}{\cos.\binom{n+\text{IV}}{n+\text{VI}}},\text{ og} \\ \cot.\binom{\varphi'}{\varphi}=-\cos.\binom{n+\text{III}}{n+\text{I}}\,.\,\text{tang.}\binom{n+\text{IV}}{n+\text{VI}}. \end{array}\right\}\S\,43.$$

Er	bliver	i Følge	naar sættes isteden for n
a) $n + III = 90°$,	$\cos.(n + II) = \frac{\cos.(n + VI)}{\cos.(n + IV)}$,	§ 49 c,	$n + V$.
b) $n + I = 90°$,	$\cos.(n + II) = \frac{\cos.(n + IV)}{\cos.(n + VI)}$,	§ 49 c,	$n + III$.
c) $n + IV = 90°$,	$\sin.(n + II) = -\frac{\cos.(n + VI)}{\cos.(n + III)}$,	§ 49 b,	$n + V$.
d) $n + VI = 90°$,	$\sin.(n + II) = -\frac{\cos.(n + IV)}{\cos.(n + I)}$,	§ 49 a,	$n + III$.

B) De to givne Siders indsluttede Vinkel udledes af følgende Formel *X*, naar sættes $n = 0$, II, eller IV.

$$X)\left\{\begin{array}{l} \sin.\binom{(n+I)+\varphi'}{(n+I)+\varphi} = -\cot.\binom{n+II}{n+VI}. \\ \qquad\qquad \tan g.\binom{n+VI}{n+II}.\sin.\binom{\varphi'}{\varphi}, \text{ og} \\ \tan g.\binom{\varphi'}{\varphi} = \tan g.\binom{n+V}{n+III}.\cos.\binom{n+VI}{n+II}. \end{array}\right\}\ \S\ 44.$$

Er	bliver	i Følge	naar for n sættes
e) $n+III=90°$,	$\cos.(n+I) = -\cot.(n+VI).\tan g(n+II)$,	§ 49 *f*,	$n+IV$.
f) $n+V=90°$,	$\cos.(n+I) = -\cot.(n+II).\tan g(n+VI)$,	§ 49 *f*.	
g) $n+VI=90°$,	$\sin.(n+I) = -\cot(n+II).\tan g(n+V)$,	§ 49 *h*,	
h) $n+II=90°$,	$\cot.(n+I) = -\cot.(n+V)\cos(n+VI)$,	§ 49 *f*,	$n+III$.

C) Den anden givne Sides modstaaende Vinkel sluttes af Formelen *XI*.

$$XI)\ \sin.(\mathrm{n}+\mathrm{I}) = \frac{\sin.(\mathrm{n}+\mathrm{IV}).\sin.\binom{\mathrm{n}+\mathrm{III}}{\mathrm{n}+\mathrm{V}}}{\sin.\binom{\mathrm{n}+\mathrm{VI}}{\mathrm{n}+\mathrm{II}}},$$

§ 39, Æqvationen *II*.

§ 51.

Naar i de tre foregaaende Opgaver, § 48, 49, 50 isteden for Sider sættes Vinkler, og isteden for Vinkler sættes Sider, opløses de ved at antage i de anførte Formler, n at være $=$ I, eller III, eller V, § 39.

§ 52.

Er i en sphærisk Triangel Siderne mindre end to rette og positive, da kan ogsaa Vinklerne antages at være af samme Beskaffenhed; thi at den første Vinkel kan tælles positiv, at være mindre end to rette, viser § 37, Fig. 6; men at de to andre Vinkler er af samme Art som den første, sees af Formlen

$$\sin.\mathrm{I} = \frac{\sin.\mathrm{IV}.\sin.\binom{\mathrm{III}}{\mathrm{V}}}{\sin.\binom{\mathrm{VI}}{\mathrm{II}}},\ \S\ 50\ XI.$$

I det følgende forudsættes Vinkler og Sider at være mindre end 180°.

§ 53.

En sphærisk Triangel bestemmes fuldkommen, hvis Siderne ere mindre end to rette, af tre givne Vinkler; tre givne Sider; to Vinkler og disses fælles Side; eller to Sider og indesluttede Vinkel, hvilket sees af Formlerne § 48, 49, og Sætningen § 51.

§ 54.

Af foregaaende Formler følger ogsaa, at ligestore Vinkler staae lige over for lige store Sider, og omvendt; f. Ex. naar i Formlen *IV* § 49 sættes I = III, da er IV = VI; thi cos. I = cos. III . cos. V — sin. III . cos. IV . sin. V, og cos. III = cos. V . cos. I — sin. V . cos. VI . sin. I. (Den sidste Æqvation faaes af den første ved at forøge Tallene med II).

§ 55.

Den større Vinkel modsættes den mindre Side, og omvendt. Følger af Formlen § 47

$$-\text{tang.}\tfrac{1}{2}(\text{I}-\text{III}) = \text{tang.}\tfrac{1}{2}\text{V}.\frac{\text{sin.}\tfrac{1}{2}(\text{IV}-\text{VI})}{\text{sin.}\tfrac{1}{2}(\text{IV}+\text{VI})};$$

thi naar I — III er negativ, maa IV — VI være positiv,

§ 56.

Hver to Sider ere tilsammen større end den tredie, og alle tre Sider tilsammen mindre end fire Rette; thi i Følge § 45 og 46 er

$$\cos{}^2\tfrac{1}{2}(\text{I}) = \frac{\text{sin.}\tfrac{1}{2}(\text{IV}+\text{II}-\text{VI}).\text{sin.}\tfrac{1}{2}(\text{IV}-\text{II}+\text{VI})}{\text{sin.II}.\text{sin.VI}}, \text{ og}$$

$$\text{sin.}^2\tfrac{1}{2}(\text{I}) = \frac{\text{sin.}\tfrac{1}{2}(\text{IV}+\text{II}+\text{VI}).\text{sin.}\tfrac{1}{2}(\text{VI}+\text{II}-\text{IV})}{\text{sin.VI}.\text{sin.II}};$$

men sættes i første Æqvation VI $>$ IV + II, saa maa ogsaa II være større end IV + VI; thi ellers blev cos.$^2\,\tfrac{1}{2}$(I) negativ;

men det er umueligt at VI kan være større end IV + II, naar II $\triangleright$ IV + VI; ej heller kan VI være = IV + II; thi da blev $\cos.^2 \frac{1}{2}$(I) = 0. Følgelig maa VI være $\triangleleft$ IV + II, og i Almindelighed to Sider større end tredie Side; altsaa er i anden Æqvation sin. $\frac{1}{2}$(VI + II — IV) positiv; altsaa ogsaa sin. $\frac{1}{2}$(IV + II + VI) positiv; følgelig $\frac{\text{IV} + \text{II} + \text{VI}}{2} \triangleleft 180°$ (§ 52), og IV + II + VI er mindre end 360°.

§ 57.

Ligeledes bevises at de to Vinkler ere tilsammen større end den tredie, og Summen af alle tre mindre end fire Rette, hvilket ogsaa følger af § 37, No. 6 *a*, og § 56.

§ 58.

Naar man paa en Halvkugle fra et Punct C (Fig 12) mellem Grundcirkelens Pol P og dens Omkreds trækker Storbuen CB ned til Grundens Peripherie[1]), da er CB mindst, naar den endes i r, hvor Perpendicularen PC forlænget skiær Grundcirkelens Omkreds; derefter voxer den fra Cr til at den bliver = 90° = rQ = CQ, og endnu derefter lige til at den bliver = 180° — Cr (= Cq), saa at B falder under QR, naar CB er stump; men er CB spids, falder B over QR.

Thi lad CBq betegnes ved I, Hypotenusen BC ved II, Catheten Cr ved IV, og rB ved VI: saa er i Følge § 49 *c* (nemlig naar sættes I isteden for n) cos. II = cos. IV . cos. VI, eller cos. BC = cos. Cr . cos. rB, hvoraf Paastandens Rigtighed letteligen indsees.

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1) Rastners Mathematikens Begyndelsesgrunde, oversat af Hr. Professor Wolf. Den sphæriske Trigonometries anden Sætning, Pag. 517.

Imedens rB voxer fra 0 til 90°, og CB fra Cr til CQ (= 90°), voxer Vinkelen CBq fra 90° til 180° — Cr; men derefter, naar rB voxer fra 90° til 180°, og CB fra 90° til 180° — Cr, aftager CBq fra 180° — Cr til 90°; thi naar i § 49 *h* isteden for n sættes v, bliver v = 90°, og — cot I = cot. IV ⋈ sin VI, eller — cot. CBq = cot. Cr . sin. rB, af hvilken Formel sætningens Beviis er let at udlede.

§ 59.

Antages en Triangels Sider (II, IV, VI) at være mindre end to Rette, og i Æqvationen $\sin. \text{I} = \frac{\sin. \text{IV} \,.\, \sin. \text{V}}{\sin. \text{II}}$ (§ 50 *XI*) Buerne IV, V, II ere skieve: da viser følgende Tabel, i hvilke Tilfælde den søgte Vinkel I er spids, stump eller tvetydig.

Er nemlig

$$\left.\begin{matrix}1\\2\end{matrix}\right\}\text{ V stump, IV stump, og II }\begin{pmatrix}\lessdot 180° - \text{IV}\\ \gtrdot 180° - \text{IV}\end{pmatrix},\text{ saa er I }\begin{pmatrix}\text{tvetydig}\\ \text{spids}\end{pmatrix}.$$

$$\left.\begin{matrix}3\\4\end{matrix}\right\}\text{ V spids, IV spids, II }\begin{pmatrix}\gtrdot 180° - \text{IV}\\ \lessdot 180° - \text{IV}\end{pmatrix},\text{ - - I }\begin{pmatrix}\text{tvetydig}\\ \text{stump}\end{pmatrix}.$$

$$\left.\begin{matrix}5\\6\end{matrix}\right\}\text{ V stump, IV spids, II }\begin{pmatrix}\lessdot \text{IV}\\ \gtrdot \text{IV}\end{pmatrix},\text{ - - I }\begin{pmatrix}\text{tvetydig}\\ \text{stump}\end{pmatrix}.$$

$$\left.\begin{matrix}7\\8\end{matrix}\right\}\text{ V spids, IV stump, II }\begin{pmatrix}\gtrdot \text{IV}\\ \gtrdot \text{IV}\end{pmatrix},\text{ - - I }\begin{pmatrix}\text{tvetydig}\\ \text{spids}\end{pmatrix}.$$

$$\left.\begin{matrix}9\\10\end{matrix}\right\}\begin{matrix}\text{II} = \text{IV, og da er I} = \text{V}.\\ \text{II} + \text{IV} = 180°, \text{ - I} = 180° - \text{V}.\end{matrix}$$

Beviis. Da ingen af Siderne i Triangelen ABC (Fig. 13—18) ere større end 180°, saa falder hele Triangelen paa en af de Halvkuglers Overflade, som afskiæres ved Planet af Siden AB (= VI), og da Siderne II og IV ere skieve, saa mødes de i et Punct C udenfor Grundcirkelens ABD Pol P. Man kan altsaa fra Polen P uddrage Storbuen PC til begge

Sider, og ligeledes dens Perpendicular QPR, til at begge naae Grundcirkelens Omkreds. Disse to Halvcirkler forestilles i Figurerne 13—18 ved de to rette Linier rq og QR.

1) Fordi IV er stump og II spids, falder A (Fig. 13) under QR, og B saavelsom det yderste Punct D af Halvcirkelen ACD falder over QR, § 58. Men da Buen $180° -$ IV ($=$ CD) forudsættes at være større end II ($=$ CB): saa maa denne falde imellem Cr og CD, eller ogsaa imellem Cr og CQ, § 58, og maa paa begge Steder kunne have samme Størrelse. I det ene Tilfælde bliver I spids, i det andet stump; altsaa er I tvetydig.

2) Da Buen II antages $\triangleright$ $180° -$ IV, eller II $\triangleright$ CD (Fig. 14), saa er CDR $\triangleleft$ CBA (§ 55), eller V $\triangleleft$ $180° -$ I; men V antages stump, altsaa er I spids.

3) IV er spids og II stump, følgelig falder A (Fig. 15) over, men B under QR. Og da Buen II $\triangleright$ $180° -$ IV, kan den i Følge § 58 have samme Størrelse, saavel mellem CD og Cq, som i ligestor men modsat Afvigning fra Cq. I kan altsaa være spids eller stump, § 68.

4) Efter Betingelsen er II $\triangleleft$ $180° -$ IV, eller II $\triangleleft$ CD (Fig 16); altsaa er i $\triangle$ CBD CDQ $\triangleright$ CBA, eller V $\triangleright$ $180° -$ I (§ 55); men V er spids, altsaa I stump.

5) II og IV antages begge spidse; altsaa ere B, A og C (Fig. 17) paa samme Side af QR (§ 58); og da antages II $\triangleleft$ IV, saa kan B falde paa begge Sider af Cr; paa den ene Side bliver I stump, paa den anden spids (§ 58), altsaa er I tvetydig.

6) II $\triangleright$ IV, altsaa V $\triangleleft$ I (§ 55); men V er stump, altsaa I stump.

7) Da II og IV ere begge stumpe, saa overskiære de Perpendicularen QR (Fig. 18) imellem Puncterne Q og R

(§ 58). Og da II $\triangleright$ IV, saa kan Buen II enten ligge imellem IV og Cq, eller paa den anden Side af Cq. Altsaa Vinkelen I enten være spids eller stump (§ 58).

8) Naar II $\triangleleft$ IV, er V $\triangleright$ I (§ 55), altsaa, naar V er spids, bliver ogsaa I spids.

9) II = IV giver V = I (§ 44).

10) II + IV = 180°, giver I = 180° — V, fordi Supplementerne til II og IV danne tilligemed AB (Fig. 19) en anden △ ABC' hvis Vinkler og Sider ere saa store som de i △ ABC (§ 53).

§ 60.

Forudsættes der ligesom i foregaaende § 59 at Triangelens Sider (II, IV, VI) ere $\triangleleft$ 180°, men i Æqvationen $\sin.\text{I} = \frac{\sin.\text{IV}\,.\,\sin.\text{V}}{\sin.\text{II}}$ (§ 50, *XI*) to af de givne Stykker (V, IV, II) er rette: da er

I = 180° — IV, hvis V og II ere rette, (Fig. 19).
I = 90° = II, - V og IV ere rette.
I = 90° = V, - IV og II ere rette.

Er derimod kun et af de givne Stykker ret; da er enten

$\left.\begin{matrix}1\\2\end{matrix}\right\}$ V ret og IV $\begin{pmatrix}\triangleright \text{II}\\ \triangleleft \text{II}\end{pmatrix}$, hvoraf følger I er $\begin{pmatrix}\text{spids}\\ \text{stump}\end{pmatrix}$, eller

$\left.\begin{matrix}3\\4\end{matrix}\right\}$ V spids, IV ret, og II $\begin{pmatrix}\text{spids}\\ \text{stump}\end{pmatrix}$, - - I er $\begin{pmatrix}\text{umuelig}\\ \text{tvetydig}\end{pmatrix}$,

$\left.\begin{matrix}5\\6\end{matrix}\right\}$ V stump, IV ret, og II $\begin{pmatrix}\text{stump}\\ \text{spids}\end{pmatrix}$, - - I er $\begin{pmatrix}\text{umuelig}\\ \text{tvetydig}\end{pmatrix}$,

$\left.\begin{matrix}7\\8\end{matrix}\right\}$ V spids, IV $\begin{pmatrix}\text{stump}\\ \text{spids}\end{pmatrix}$ og II ret, - - - I er $\begin{pmatrix}\text{spids}\\ \text{stump}\end{pmatrix}$,

$\left.\begin{matrix}9\\10\end{matrix}\right\}$ V stump, IV $\begin{pmatrix}\text{stump}\\ \text{spids}\end{pmatrix}$ og II ret, - - - I er $\begin{pmatrix}\text{spids}\\ \text{stump}\end{pmatrix}$, Beviis. No. 1 og 2 følge deraf, at den større Side staaer lige over for den mindre Vinkel (§ 63).

No. 3 og 5 ere umuelige; thi naar IV er ret, kan V og II hverken være begge spidse, eller begge stumpe, fordi $-\cot.\,\text{II} = \cot.\,\text{V}\,\sin.\,\text{III}$ (§ 49 *e*).

I 7, 8, 9, 10 ere I og V af forskiellieg Slags, fordi naar $\text{II} = 90^\circ$ er $-\cot.\,\text{IV} = \cot.\,\text{I}\,.\,\sin.\,\text{III}$, hvilket følger af § 49 *h*, naar antages $\text{n} = \text{II}$.

No. 4 og 6 kan bevises saaledes: Enten II er stump og V spids, som i No. 4, og i △ ABC Fig. 20, eller II er spids og V stump, som No. 6, og i △ACB': saa kan der formeres af II tilligemed Supplementerne til IV og VI en anden △ A'BC, eller A'B'C, hvori II, IV og V beholde samme Størrelse; men Vinkelen I forandres i sit Supplement. Følgelig kan der af samme Data II, IV, V dannes to forskjellige Triangler.

§ 61.

I Følge § 37 No. 6 *a* kan enhver Triangel forvandles til en anden, hvori Vinklerne ere den forrige Triangels Sider, og Siderne den forriges Vinkler, Ordenen forresten uforandret. Følgelig naar af VI, V, III givne skal findes II efter Formlen $\sin.\,\text{II} = \frac{\sin.\,\text{V}\,.\,\sin.\,\text{VI}}{\sin.\,\text{III}}$: kan det Givne og Søgte betegnes ligesom i § 59, 60, og de der anførte Regler ogsaa i dette Tilfælde anvendes.

§ 62.

Da Formlerne *IX* og *X* § 50 ere udledte af en Æqvation, den indeholder baade Cosinus og Sinus af den søgte Bue: saa kunde formodes at de ikke skulde, som Æqv. *XI*,

§ 50, give det Søgte nogen positiv Værdie, som var mindre end 180°, og ei stemte overens med Triangelens Data, naar disse vare alle positive og mindre end to Rette; men for herom fuldkommen at overbevises, sætter jeg:

1) At $n' + ii'$ er positiv, mindre end to Rette, og en Værdie af $n + ii$, der ved Hielp af *Æqv. IX*, § 50 er beregnet af de Data: $n + iii$, $n + iv$, $n + vi$. Dernæst slutter jeg, at i en Triangel, hvori gives $n' + ii'$, $n + iii$ og $n + iv$, og hvori det som staaer lige over for $n' + iii$ kaldes $n' + vi'$, er i Følge § 49 *IVde Æqv.* $\cos.(n' + vi') = \cos.(n' + ii') . \cos.(n + iv) - \sin.(n + ii) . \cos.(n + iii(. \sin.(n + iv)$; men den samme Værdie faaer sos. $(n + vi)$, naar i Æqvationen $\sin.[(n' + ii') + \varphi'] = \frac{\cos.(n + vi)}{\cos.(n + iv)} . \sin.\varphi'$ (§ 50 *IX*) Sinus til Summen udtrykkes ved Parternes Cosinus og Sinus, derefter divideres med $\sin.\varphi'$, og tilsidst sættes $-\cos.(n + iii) \times \text{tang.}(n + iv)$ isteden for $\cot.\varphi'$. Følgelig bliver $n + iv = n' + vi'$, og altsaa kan den beregnede Værdie $n' + ii'$, og de givne Stykker $n + iii$, $n + iv$, $n + vi$ tilhøre en og den samme Triangel.

2) Ligeledes antager jeg i *Xde Æqv.* § 50 at $n' + i'$ er en Værdie af $n + i$, tillige at den er positiv, mindre end 180°, og beregnet af de Data $n + ii$, $n + v$, $n + vi$; derefter slutter jeg i Følge § 49 *Æqvat. VI*, at i en Triangel hvori gives $n' + i'$, $n + v$ og $n + vi$, og hvori det $n + v$ modstaaende Stykke betegnes ved $n' + ii$, er
$$-\cot.(n' + ii') = \frac{\cot.(n + v) . \sin(n' + i')}{\sin.(n + vi)} + \cot.(n + vi) .$$
$\cos.(n' + i')$, eller ved at dividere med $\cot.(n + vi)$,
$$-\cot(n' + ii') . \text{tang.}(n + vi) = \frac{\cot.(n + v) . \sin.(n' + i')}{\cos.(n + vi)} +$$

cos. $(\bar{n}+\bar{\mathrm{I}})$; men denne samme Formel udkommer for cot. $(n+\mathrm{II})$, naar i Æqvationen X § 50 sin. $[(\bar{n}+\bar{\mathrm{I}})+\varphi']$ udtrykkes ved Cosinus og Sinus af $\bar{n}+\bar{\mathrm{I}}$ og af φ', der-efter divideres med sin. φ', og tilsidst sættes isteden for cot. φ' dens Værdie; følgelig er $\bar{n}+\bar{\mathrm{II}}=n+\mathrm{II}$, og altsaa høre $\bar{n}+\bar{\mathrm{I}}$, $n+\mathrm{II}$, $n+\mathrm{V}$, $n+\mathrm{VI}$ til samme Triangel.

§ 63.

Saaledes kan der ogsaa construeret en Triangel, hvis Sider og Vinkler ere mindre end to Rette, af to i hver af Æqvationerne, *c*, *d*, *g*, § 50 givne Stykker tilligemed det Søgtes Værdie, naar denne kun er positiv og under 180°; tillige kan bevises, at det tredio givne Stykke ogsaa tilhører den construerede Triangel, følgelig at det Søgtes beregnede Værdie alletider kan bestaae med de givne Stykker; f. Ex. i Følge § 50 *c* er $n+\mathrm{IV}=90°$, og $\sin.(n+\mathrm{II})=-\dfrac{\cos.(n+\mathrm{VI})}{\cos.(n+\mathrm{III})}$, lad nu $\bar{n}+\bar{\mathrm{II}}$ være det Søgtes Værdie, og af $\bar{n}+\bar{\mathrm{II}}$, $n+\mathrm{IV}$ og $n+\mathrm{III}$ lad construeres en Triangel, hvori det som staaer lige øver for $n+\mathrm{III}$ kaldes $\bar{n}+\bar{\mathrm{VI}}$: saa er cos. $(\bar{n}+\bar{\mathrm{VI}})=-\sin.(\bar{n}+\bar{\mathrm{II}}).\cos.(n+\mathrm{III})$ § 49 *b*; men cos. $(n+\mathrm{VI})$ er ogsaa $=-\sin.(\bar{n}+\bar{\mathrm{II}}).\cos.(n+\mathrm{III})$, § 50 c; altsaa $n+\mathrm{VI}=\bar{n}+\bar{\mathrm{VI}}$.

Jeg tilføier endnu følgende, for at vise, hvordan de i 30te og 31te § antagne Directionstegn kunne anvendes til at udtrykke en Æqvation for retlinede Polygoner, hvis Sider udstrækkes i forskiellige Planer.

§ 64.

Et Polygon af omtalte Beskaffenhed er ubestemt, naar det har fire Sider af ubekiendt Længde.

Beviis.

1) Lad de fire af Længde ubekiendte Sider følge efter hinanden, og være ab, bc, cd og de, Fig. 21. Hvis da Puncterne a, b og c ere i en ret Linie, kan ab forkortes, og cb ligesaa meget forlænges, uden at disse to Liniers Direktion, eller de øvriges Direction og Længde paa nogen Maade forandres. Altsaa ere de to Polygonets Sider i dette Fald ubestemte.

Er hverken abc eller cde en ret Linie, men abc er i samme Plan som cde; da kan i dette Plan udenfor Punctet c, drages med bc og cd Paralleler, som skiære ab og de. Altsaa er ogsaa i dette Fald Polygonet ubestemt.

Er Triangelen abc ikke i samme Plan som Triangelen cde; da maae dog disse Trianglers Planer skiære hinanden i en ret Linie dragen igiennem Punctet c, og fra Puncter i denne Linie, udenfor c, maae kunne trækkes med cd og bc Paralleler, som skiære ab og de. Altsaa bliver endnu Polygonet ubestemt.

2) Siderne af ethvert retliniet Polygon kan man give hvad Orden man vil, uden derved at forandre deres Sum, Direction og Længde, § 2. Altsaa, dersom ab, bc, cd og de ei følge efter hinanden i uafbrudt Orden, ligesom i de foregaaende Beviis er antaget: da kan man forestille sig et andet Polygon, hvori Siderne ere de samme, men de fire af Længde ubekiendte ere i et

sammenhængende Følge. Og da nogle af disse fire kunne i denne Orden have uendelig mange Værdier efter første Beviis: saa maa de ogsaa kunne have ligesaa mange, naar de igien omsættes i forrige Orden, § 2.

§ 65.

I ethvert retliniet Polygon, hvori Siderne ei ligge alle i samme Plan, forudsættes, hver Side at begynde der, hvor foregaaende ophører, hvorfor ogsaa Summen af dem alle bliver = 0 i Følge § 2. Dernæst antages, at Længden af første, anden, tredie, . . ., mte eller sidste Side betegnes ved et Mærke af samme Orden i Rækken $|\overline{\text{I}'}$, $|\overline{\text{III}'}$, $|\overline{\text{V}'}$, $\overline{\text{VII}'}$, . . ., $|\overline{(2\text{m}-\text{I})'}$, og Siderne selv i den Orden, de følge hinanden, ved de uefne Tal I', III', V', VII', . . ., $(2\text{m}-\text{I})'$ med en tilføiet Tøddel øverst til høire Haand for at skille Siden fra Vinkelen, som Planet igiennem samme Side og foregaaende giør med Planet igiennem hiin og følgende Side,; thi disse Planernes Vinkler betegnes ogsaa ved Tallene I, III, V, . . ., (2m — I); saa at I (Fig. 22) er de to Planers Vinkel, der overskiære hinanden i Linien I', eller Vinkelen mellem Planerne CDA og DAB; III Vinkelen mellem dem, der overskiære hinanden i Linien III', eller Vinkelen mellem Planerne DAB og ABC, o. s. f. (2m ÷ I) er Vinkelen, som Planet igiennem sidste og første Side giør med Planet giennem sidste og næstsidste.

End videre antages, at Vinkelen, som hver Side afviger fra foregaaendes Forlængning, betegnes ved det efne Tal II, IV, VI, . . ., eller 2m, hvilket er een Unitet større end foregaaende Sides Tal; II er nemlig Vinkelen, som

IIIᵘ afviger fra Forlængningen af Iᵘ; IV er Vinkelen, som Vᵘ afviger fra Forlængningen af IIIᵘ, o. s. f., 2m er Vinkelen, som første Side Iᵘ afviger fra sidste Sides (2m—1)ᵘ Forlængning.

§ 66.

Alle disse saavel Planernes som Sidernes Vinkler kan man antage for positive, og efter eget Tykke fastsætte, om en Sides Afvigning fra foregaaendes Forlængning skal tages for større eller mindre end to Rette. Men efterat dette er fastsat, bliver det ei længere ligegyldigt, hvordan Planernes Skraahed skal maales, om ellers Reglerne for disse Polygoners Opløsning skulde giælde for alle Tilfælde.

§ 67.

Skal Planernes indbyrdes Hældning efter een og den samme Regel maales, maa man forestille sig tre af Polygonets Sider, der følge i sammenhængende Rad efter hinanden, ligesom i Fig. 23 Linien fra a til b, den fra b til c, og den fra c til d; derefter drage fra midterste Sides bc sidste Punct c en Parallel cf med foregaaende Side ab; beskrive om samme Punct c som Centner fra Parallelen cf til midterste Sides Forlængning cg en Cirkelbue fg, der maaler den Vinkel cbe, som midterste Side afviger fra foregaaendes Forlængning be; ligeledes om samme Centner og og med samme Radius en Cirkelbue gi fra midterste Sides Forlængning cg til følgende Side cd. Den spæriske Vinkel igh, som den sidst beskrevne Bue gi afviger fra Forlængningen gh af den første Bue fg, bliver da saa stor som Vinkelen, Planet igiennem midterste og følgende Side afviger fra Planet igiennem midterste og foregaaende, eller saa stor som Planets bcd Afvigning fra Planet abc. Og denne Vinkel maales paa den Maade, at, naar man paa Sphæren følger Buen fg, og kommer fra f til g, saa gaaer Vinkelens Maal fra Forlængningen af fg til venstre Haand. Saaledes kunne disse Vinkler bestemmes, naar man i et Polygon vil vide nogle af dem, for at kunne beregne de øvrige.

§ 68.

Men er Sidernes Directioner i et Polygon Fig. 22 paa lidet nær bekiendte, kunne dets Vinkler tydeligere forestilles, naar fra Centret c af *Kuglen* wpho (Fig. 24) drages de Radier c𝔄, c𝔅, cℭ og c𝔇 af den Direction, at hver for sig bliver parallel med Siden af samme Orden i Rækken I^v, III^v, V^v, VII^v, Fig. 22; thi da faaes ved at drage Storbuerne 𝔄𝔅. 𝔅ℭ, ℭ𝔇 og 𝔇𝔄 et sphærisk Polygon 𝔄𝔅ℭ𝔇, hvoraf Siderne maale det retliniede Polygons Vinkler II, IV, VI, VIII, og de sphæriske Vinkler ere de samme som Planernes Vinkler I, III, V, VII i den retlinede Figur 22[1]). For et saadant Polygons Vinkler har man altsaa samme Æqvation som for et sphærisk Polygon, nemlig s „ I′ „ II′ „ III′ „ IV′ „ . . . „ (2m)′ = s (§ 37). s kan her betegne enhver ret Linie, og 2m er det retlinede Poligons sidste

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1) Efter Tegningen Fig. 24 og Reglen § 67 ere Vinklerne III og VII større, men Vinklerne I og V mindre end 180°. At V falder under Projectionsplanet, gjør at Siden VI synes at ligge til Høire, da den dog falder til Venstre for den, der paa Sphæren følger Buen IV fra 𝔅 til ℭ.

Vinkel, eller første Sides Afvigning fra den mte (det er den sidste Sides Forlængning.

§ 69.

Nu sætter jeg, at 𝔄wγhp (Fig 24) er Horizonten, 𝔄πqυ er Verticalcirkelen, 𝔄 er begge Cirklers fælles Nulpunct; de horizontale Buer tælles positive til Venstre, og de verticale positive opad; Radius c𝔄 = + I, cγ = ε, cπ = η, og hver to af disse Radier indeslutte en ret Vinkel, ligesom tilforn er antaget § 24 og 25. Jeg sætter endnu, at Spidsen af Polygonets 𝔄𝔅ℭ𝔇 første Vinkel I falder i Horizontens og Verticalens fælles Nulpunct 𝔄, og at Forlængningen af den sidste Side VIII falder i Verticalen 𝔄υ under Horizonten. Dette forudsat, er Radius cv = η „ IV′ „ III′ „ II′ „ I′ „ (— η), og i Almindelighed, hvis det sphæriske Polygons sidste Side 2m er vertical, og endes i Nulpunctet 𝔄, men gaaer forlænget under Horizonten, og i denne Kuglens Position drages Radius c(n + I) til Spidsen af Vinkelen (n + I), eller til sidste Punct af Polygonens Side n: saa er samme Radius c(n + I) = η „ n′ „ (n — I)′ „ (n — II)′ „ . . . „ II′ „ I′ „ (— η).

For at bevise denne Sætning antager jeg den horizontale og den verticale Cirkel for ubevægelige, ligesom i § 37, og lader Kuglen fra omtalte Position (Fig 24) først omvæltes 90 verticale Grader, derefter de horizontale Grader I, saa de vertisale II, dernæst de horizontale III, o. s. f., tilsidst de verticale Grader n. Derved forflyttes Spidsen af Vinkelen (n + I) saa mange Grader, som Kuglen er omvæltet, og i Følge § 33 forandres derved Radius c(n + I)

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først til $c(n+\text{I}) \,„\, \eta$, derpaa til $c(n+\text{I}) \,„\, \eta \,„\, \text{I}'$, dernæst til $c(n+\text{I}) \,„\, \eta \,„\, \text{I}' \,„\, \text{II}'$, saa til $c(n+\text{I}) \,„\, \eta \,„\, \text{I}' \,„\, \text{II}' \,„\, \text{III}'$ o. s. f., omsider forandres den til $c(n+\text{I}) \,„\, \eta \,„\, \text{I}' \,„\, \text{II}' \,„\, \text{III}' \,„\, \ldots \,„\, (n-\text{I})' \,„\, n'$, og bliver saa stor som η, fordi det sidste Punct af Siden n, og altsaa det sidste af Radius $c(n+\text{I})$, falder nu i Horizontens Pol π. Af Æqvationen $c(n+\text{I}) \,„\, \eta \,„\, \text{I}' \,„\, \text{II}' \,„\, \text{III}' \,„\, \ldots \,„\, (n-\text{I})' \,„\, n' = \eta$ sluttes, i Følge § 33: $c(n+\text{I}) = \eta \,„\, \bar{n}' \,„\, \overline{(n-\text{I})}' \,„\, \ldots \,„\, \overline{\text{II}}' \,„\, \bar{\text{I}}' \,„\, (-\eta)$, hvilket var det som skulde bevises.

§ 70.

Efter foregaaende Formel er derfor i Figur 24 $c\text{I} = 1$, $c\text{III} = \eta \,„\, \overline{\text{II}}' \,„\, \bar{\text{I}}' \,„\, (-\eta)$, $c\text{V} = \eta \,„\, \overline{\text{IV}}' \,„\, \overline{\text{III}}' \,„\, \overline{\text{II}}' \,„\, \bar{\text{I}}' \,„\, (-\eta)$ o. s. f. Desuden er, efter Betingelsen § 68, $c\text{I}$ parallel med I^υ, $c\text{III}$ med III^υ, $c\text{V}$ med V^υ, &c., Fig 22. Altsaa er $\text{I}^\upsilon = c\text{I} . |\overline{\text{I}^\upsilon}$, $\text{III}^\upsilon = c\text{III} . |\overline{\text{III}^\upsilon}$, $\text{V}^\upsilon = c\text{V} . |\overline{\text{V}^\upsilon}$ &c. og $(2m-\text{I})^\upsilon = c(2m-\text{I}) \bowtie |\overline{(2m-\text{I})^\upsilon}$, § 65, (ved $(2m-\text{I})^\upsilon$ forstaaes det retlinede Polygons mte og sidste Side. Videre, da $\text{I}^\upsilon + \text{III}^\upsilon + \text{V}^\upsilon + \ldots + (2m-\text{I})^\upsilon = 0$, § 2: saa er ogsaa $|\overline{\text{I}^\upsilon} + |\overline{\text{III}^\upsilon} . c\text{III} + |\overline{\text{V}^\upsilon} . c\text{V} + \ldots + |\overline{(2m-\text{I})^\upsilon} . c(2m-\text{I}) = 0$, og naar i denne Æqvation isteden for Radii $c\text{III}$, $c\text{V}$, $c\text{VII}$, ..., $c(2m-\text{I})$ sættes deres Værdier efter § 69 og derpaa det yderste Punct af hver Radius forflyttes 90 verticale Grader, udkommer Æqvationen $|\overline{\text{I}^\upsilon} . \eta + |\overline{\text{III}^\upsilon} . \eta \,„\, \overline{\text{II}}' \,„\, \bar{\text{I}}' + |\overline{\text{V}^\upsilon} . \eta \,„\, \overline{\text{IV}}' \,„\, \overline{\text{III}}' \,„\, \overline{\text{II}}' \,„\, \bar{\text{I}}' + |\overline{\text{VII}^\upsilon} . \eta \,„\, \overline{\text{VI}}' \,„\, \bar{\text{V}}' \,„\, \overline{\text{IV}}' \,„\, \overline{\text{III}}' \,„\, \overline{\text{II}}' \,„\, \bar{\text{I}}' + \ldots + |\overline{(2m-\text{I})^\upsilon} . \eta \,„\, \overline{(2m-\text{II})}' \,„\, \overline{(2m-\text{III})}' \,„\, \ldots \,„\, \overline{\text{II}}' \,„\, \bar{\text{I}}' = 0$, hvoraf endnu, om skulde behøves, kan udelades $\bar{\text{I}}'$ paa den § 33 omtalte Maade.

§ 71.

Man har ogsaa for ethvert retlinet Polygon, hvori Siderne ei lige i samme Plan, følgende to Æqvationer:

A) $s \text{ „ } \mathrm{I}' \text{ „ } \mathrm{II}' \text{ „ } \mathrm{III}' \text{ „ } \mathrm{IV}' \text{ „ } \mathrm{V}' \text{ „ } \ldots \text{ „ } (2m)' = s$, § 68, og

B) $|\overline{\mathrm{I}^{\cup}} \cdot \eta + |\overline{\mathrm{III}^{\cup}} \cdot \eta \text{ „ } \mathrm{II}^{-\prime} \text{ „ } \mathrm{I}^{-\prime} + |\overline{\mathrm{V}^{\cup}} \cdot \eta \text{ „ } \mathrm{IV}^{-\prime} \text{ „ } \mathrm{III}^{-\prime} \text{ „ } \mathrm{II}^{-\prime} \text{ „ } \mathrm{I}^{-\prime} + |\overline{\mathrm{VII}^{\cup}} \cdot \eta \text{ „ } \mathrm{VI}^{-\prime} \text{ „ } \mathrm{V}^{-\prime} \text{ „ } \mathrm{IV}^{-\prime} \text{ „ } \mathrm{III}^{-\prime} \text{ „ } \mathrm{II}^{-\prime} \text{ „ } \mathrm{I}^{-\prime} + \ldots + |\overline{(2m - \mathrm{I})^{\cup}} \cdot \eta \text{ „ } (2m - \mathrm{II})^{-\prime} \text{ „ } (2m - \mathrm{III})^{-\prime} \text{ „ } \ldots \text{ „ } \mathrm{III}^{-\prime} \text{ „ } \mathrm{II}^{-\prime} \text{ „ } \mathrm{I}^{-\prime} = 0$, § 70.

At disse Æqvationer maa kunne forstaaes uden Hielp af det foregaaende, vil jeg her igientage Tegnenes Betydning.

Siderne tælles saaledes at den foregaaende ophører der, hvor den følgende begynder.

Polygonets første, anden, tredie, . . ., mte eller sidste Side betegnes efter Ordenen ved $\mathrm{I}^{\cup}$, $\mathrm{III}^{\cup}$, $\mathrm{V}^{\cup}$, $\mathrm{VII}^{\cup}$, . . ., $(2m - \mathrm{I})^{\cup}$, Fig. 22.

Siderues Længder ved $|\overline{\mathrm{I}^{\cup}}$, $|\overline{\mathrm{III}^{\cup}}$, $|\overline{\mathrm{V}^{\cup}}$, $|\overline{\mathrm{VII}^{\cup}}$, . . . , $|\overline{(2m - \mathrm{I})^{\cup}}$.

Hver Sides Afvigning fra foregaaende Sides Forlængning ved et effent Tal II, IV, VI, . . ., eller 2m, som er een Unitet større end det uefne, der tiener til foregaaende Sides Mærke.

Vinkelen, som Planet igiennem den midterste og følgende af de tre sammenhængende Sider, afviger fra midterste og foregaaende Plan, betegnes ved det uefne Tal I, III, V, &c., eller (2m — I), der tilhører den midterste Side.

Alle Vinklerne ere positive. Om de skal være større eller mindre end to, Rette, sees bedst af § 66 og 67.

Vinklerne II, IV, VI, . . ., 2m maales i Verticalen, eller i en Cirkel, der staaer sænkret paa Horizonten, hvori Vinklerne I, III, V, VII, . . ., (2m — I) maales, § 25. Begge Cirkler overskiære hinanden i Radius + I.

Sinus til 90 Grader, eller $\sqrt{-1}$ (§ 6), betegnes i den verticale Cirkel ved η, og i den horizontale ved ε; ε^2 saavelsom η^2 er = — 1, i Følge § 5.

Sætter man at n er = II, IV, . . ., eller 2m, da betegnes cos. n + η sin. n ved n', og $\frac{1}{\cos. n + \eta \sin. n}$ ved $n^{-\prime}$, § 7.

Er n = I, III, V, . . ., eller (2m — I), da betyder n' det samme som cos. n + ε sin. n, og $n^{-\prime}$ det samme som $\frac{1}{\cos. n + \varepsilon \sin. n}$, § 7.

Cos. n og sin. n ere i første og tredie Qvadrant ligestilte (af samme Retning), men i anden og fierde modsatte, § 6.

Tegnet „ har kun halv den Betydning som det sædvanlige Multiplicationstegn; thi den Linie i Multiplicandums Udtryk, der ligger udenfor Planet af Cirkelbuen i Multiplicators Mærke, bliver ved Operationen uforandret; naar f. Ex. 2, 3ε og 4η ere rette Linier, da er (2 + 3ε + 4η) „ II' det samme som 3ε + (2 + 4η) . (cos. II + η sin. II); ligeledes er (2 + 3ε + 4η) „ I' det samme som 4η + (2 + 3ε) . (cos. I + ε sin. I).

Desuden maa iagttages, at Operationen skeer i den Orden, som Factorerne følge hinanden fra Venstre til Høire; saaledes maa man f. Ex, naar Værdien af (2 + 3ε + 4η) „ I' „ II' skal findes, forst søge Værdien af (2 +

$3\varepsilon + 4\tilde{\eta}$) „ I' $\left(\begin{array}{r}= 4\eta + 2\cos.\text{I} + 2\varepsilon\sin.\text{I} \\ -3\sin.\text{I} + 3\varepsilon\cos.\text{I}\end{array}\right)$, og derefter Værdsen af $\left(\begin{array}{r}4\eta + 2\cos.\text{I} + 2\varepsilon\sin.\text{I} \\ -3\sin.\text{I} + 3\varepsilon\cos.\text{I}\end{array}\right)$ „ II'.

s kan betegne en ret Linie af hvad Længde og Direction man vil; saaledes kan man i Æqvationen *A* sætte isteden for s et Led af Æqvationen B, og derved forandre Ledets Udtryk; Er f. Ex. s = $|\overline{\text{III}^v}$. η „ II'„ I' = det andet Led i *B*, da forvandles Æqvationen *A* til $|\overline{\text{III}^v}$. η „ IV'„ V'„ VI'„ . . . „ (2m)' = $|\overline{\text{III}^v}$. η „ II'„ I', § 32.

Videre har jeg ikke gaaet i disse Polygoners Undersøgelse.

DEVELOPMENT OF

ESTHERIA PACKARDI,

AS SHOWN BY ARTIFICIAL HATCHING
FROM DRIED MUD.

BY

G. O. SARS.

WITH 4 AUTOGRAPHIC PLATES.

KRISTIANIA OG KJØBENHAVN
ALB. CAMMERMEYERS FORLAG
(LARS SWANSTRØM).

KRISTIANIA — CENTRALTRYKKERIET 1896.

Development of **Estheria Packardi**, Brady, as shown by artificial hatching from dried mud.

With 4 autographic plates.

By G. O. Sars.

Introduction.

At the commencement of June this year, I received, through the kindness of Mr. Whitelegge, several samples of dried mud collected by him in the early days of April from shallow pools in the neighbourhood of Sydney, and I have thereby been enabled to continue my hatching experiments also during the past summer. From 2 of the samples, taken, according to the label, from pools «off Botany Road, near Waterworks Bridge», besides the usual Entomostraca, a considerable number of larvæ of a Phyllopod also developed. This Phyllopod turned out to be the *Estheria Packardi*, Brady, described from alcoholic specimens by the author in a previous paper inserted in these Archives, together with several other Australian Phyllopods. Having now had an opportunity of studying the whole larval and post-larval development of this form, I propose, in the present paper, to give a short account of my observations concerning that part of the biology of the said interesting Phyllopod. In another paper, to be published shortly, I intend to treat of the other Entomostraca raised from the mud.

Although a considerable number of larvæ were successfully hatched in my aquaria, it was only a comparatively small number of them that accomplished their whole development, and but very few specimens grew to their full size. Notwithstanding this, all the developmental stages, both larval and postlarval, have been carefully studied, and numerous drawings from living specimens executed, the most instructive of which are reproduced, by the autographic method, on the accompanying Plates.

In a previous paper, inserted in the Transactions of the Scientific Society of Christiania for 1887, and containing a description of the remarkable Phyllopod, *Cyclestheria Hislopi* (Baird), which I succeeded in raising from mud collected near Rockhampton, the development is also treated of in detail. But the development of this form is very different from that in other Phyllopods, the brood being, as in the Cladocera, kept within the shell of the parent until their full development, whereby any true metamorphosis in this form is excluded.

Now it appears to me rather interesting to compare therewith the development of the present Phyllopod, which, like most other forms of the sub-order, passes through a very pronounced larval metamorphosis On the whole, the development of the present form agrees very closely with that of *Limnadia lenticularis* Lin., which also I have had an opportunity of studying in detail.

I. Larval stages.

The larval development may conveniently be divided into 6 successive stages, to be described below, each of the stages being characterised by several well-marked changes in the organisation of the larva. During this period, which comprises about 4 days, the larva casts off its skin several times, though the stages here described do not in every case seem to be accompanied by a true exuviation.

First larval stage.

(Pl. I, figs. 1 & 2).

The recently hatched larva is very small, scarcely exceeding in length 0,20 mm. It exhibits all the characters of a true «Nauplius», being even somewhat simpler than the well-known typical Copepod-Nauplius, in so far as one of the 3 pairs of limbs characterising the Nauplius-stage, viz., the antennulæ, are quite rudimentary.

The body is divided by a median instriction into 2 divisions of nearly equal size, the anterior one representing the cephalon, the posterior the still quite simple and unsegmented trunk. The anterior division is very convex above, and, as it were, bulbously inflated, being obtusely rounded in front; the posterior one exhibits a regular oval form and has posteriorly a very slight notch.

Quite anteriorly, just within the frontal part, a very conspicuous, purplish red pigmentary patch, of a somewhat irregular quadrangular form, is seen. This is the simple eye or ocellus. Of the compound eye, on the other hand, not the slightest trace is yet to be detected.

The head is produced ventrally (see fig. 2) into a large, shield-like plate extending posteriorly beyond the limit of the 2 body-divisions, and representing the greatly developed anterior lip or labrum. It covers over the place, where the oral opening is to be formed, and exhibits a regular oval form, with the edges evenly curved.

Of the 3 pairs of Nauplian limbs, as above stated, those of the anterior one, the antennulæ, are still quite rudimentary, only forming, on each side of the frontal part, a very small, knob-like prominence tipped by a slender and delicate sensory bristle. The 2nd pair of Nauplian limbs, the antennæ, are, on the other hand, very largely developed, constituting the chief locomotory organs of the larva. They originate from the sides of the anterior division, and are extended laterally as a pair of powerful arms, but being very mobile, they admit of being bent, now anteriorly, now posteriorly, and it is indeed by such movements that the animal is propelled through the water. The proximal part of these limbs forms a rather thick and very flexible scape, from the base of which, somewhat ventrally, a conical process issues, pointing posteriorly, and tipped by a single, spine-like bristle. At the end of the scape, moreover, a strong posteriorly curving seta is seen to originate. The distal part of the limb is represented by 2 unequal rami issuing close together from the tip of the scape. The outer ramus is the larger, and of a somewhat fusiform shape, being provided with 4 strong setæ, 2 of which issue from the tip, the other 2 from slight notches on the inner edge. The inner ramus is nearly cylindric in form, and carries on its tip 3 strong setæ accompanied by a small, dentiform process.

The 3rd pair of Nauplian limbs, the mandibular feet, originate on each side of the median instriction of the body from a rounded prominence, which represents the mandibular body, and are, like the antennæ, extended laterally, pointing generally obliquely behind. They are scarcely more than half as long as the antennæ, and form each a simple stem, movably articulated to the above-mentioned prominence, and divided into 3 imperfectly defined segments. It is provided with 6 short, spiniform appendages, 3 of which issue from the tip, the other 9 from the inner edge, 2 of the latter being placed close together on the 1st segment.

The body of the larva is of a greyish white colour, being filled with an opaque granular matter, partly extending into the bases of the limbs. Of inner organs, besides the ocellus, only a very faint trace of the intestine is discerned in the axis of the body. On the whole, as yet only at very slight differentiation of the tissues seems to have taken place.

The motions of the larva in this stage are still rather imperfect and abrupt. At times it certainly moves the antennæ violently; but, as their setæ are still without cilia, the body cannot at any regular rate be propelled through the water, but very soon sinks again to the bottom. It is only after the 1st exuviation has taken place, that the motions acquire that regular and rhythmical character that distinguishes the larva in the succeeding stages. By this exuviation the larva passes immediately into the next stage.

Second larval stage.

(Pl. I, figs. 3 & 4).

In this stage the body of the larva has become rather more elongated, attaining now a length of 0,34 mm.

The form of the anterior division is nearly unaltered, whereas the posterior one has changed from the original regular oval form to an almost cylindrical shape, and now considerably exceeds in length the anterior. It terminates in 2 short, juxtaposed projections (the furca), separated by a small sinus, in which the anal orifice has been formed, but is otherwise quite simple, without any trace of segmentation or of true appendages. As in the preceding stage, it is for the greater part filled with an opaque granular matter, whereas the anterior division has become considerably more transparent.

The ocellus, as also the antennulæ, both in this and in all the succeeding larval stages, does not exhibit any changes whatever.

The antennæ, on the other hand, appear somewhat more fully developed, all the setæ being now densely plumose. Moreover each of the rami has acquired an additional seta, the number of the setæ being accordingly on the outer ramus 5, on the inner 4, the latter issuing all close together from the tip of the ramus. The basal process has assumed the form of a strong falciform seta, originating with a thickened base from the lower face of the scape, and having its outer part densely ciliated. The seta at the end of the scape has also become considerably stronger, and is likewise distinctly ciliated.

The mandibular feet have preserved their form and size unaltered; but the short spiniform appendages found in the preceding stage are now transformed into bristles, those issuing from the inner edge being densely ciliated. The mandibular bodies are more distinctly developed, with their masticatory part in process of formation.

The labrum (see fig. 4) exhibits a similar shield-like shape to that found in the 1st stage, and is now to a certain extent mobile, admitting of being somewhat raised and again bent in against the body. Immediately inside its terminal edge, several very large and distinctly nucleolar cells are seen, apparently of secretory nature.

The alimentary tube appears now rather distinctly in the axis of the body, being filled with yellowish contents, which become dark brown in its posterior part. It is considerably dilated in front, and exhibits here on each side a short auricular expansion, the first intimation of the richly ramified liver found in the adult animal. Posteriorly it terminates with a very distinctly defined, and rather narrow rectum, from which delicate muscular fibres radiate to the walls of a surrounding cavity.

The larva now moves rather quickly through the water by rhythmical strokes of the powerful antennæ. By every stroke the basal falciform process is seen to be thrown in between the labrum and the body, towards the now formed oral orifice, and it is therefore very probable that this process is of essential service for bringing nourishing matter to the mouth, for which reason it may properly be termed the masticatory process of the antennæ.

Third larval stage.

(Pl. I, fig. 5).

This stage immediately succeeds the preceding one, being however rather sharply marked off from the same by a previous complete exuviation of the larva, whereby some very conspicuous changes have taken place.

The form of the body appears still more elongated than in the preceding stage, and the posterior division has now assumed a more conical form, being considerably tapered in its outer part. At the base, it exhibits on each side a rather conspicuous swelling, indicating the place where subsequently the lateral parts of the carapace are to be formed, but is otherwise as yet quite simple. The furcal projections have however become considerably more elongated than in the preceding stage, forming 2 pointed lappets separated by a deep sinus.

As to the limbs, at least one very conspicuous change has taken place. This change affects the masticatory processes of the antennæ, which now appear considerably stronger, and have divided at the end in a fork-like manner into 2 somewhat unequal and densely ciliated points. It is evident that this modification renders these processes still more suitable as auxiliary organs for the procuring of food.

Fourth larval stage.

(Pl. I, figs 6 & 7).

Though this stage does not appear to be marked off from the preceding one by any true exuviation, it is, however, pronouncedly distinguished by the first apparition of the carapace and of the anterior pairs of legs, these parts having developed inside the larval skin.

The carapace, or rather the first intimation of such, presents itself as a rather small, semilunar fold extending dorsally over the most anterior part of the trunk, and having its posterior edge deeply emarginated in the middle (see fig. 6). The lateral parts of this fold represent the valves of the shell in the adult animal, and are not yet defined from each other, but are confluent dorsally. They exhibit each a distinct, narrow linguiform marking, which is the first trace of the shell-gland. Behind this rudiment of the shell appear on each side a regular series of 4 bud-like prominences, which constitute the first trace of the 4 anterior pairs of branchial legs. They are, as above stated, like the developing shell, enclosed within the larval skin, which passes over them without any interruption.

In the Nauplian limbs no perceptible change has taken place, and the labrum, the ocellus and the alimentary tube also exhibit the very same appearance as in the 2 preceding stages.

The body has, however, now become very transparent, and the differentiation of the tissues has proceeded, so as to show rather distinctly the several muscles moving the antennæ and mandibular feet (see fig. 6). The length of the larva in this stage is 0,42 mm., and accordingly but very little greater than in the preceding stage.

Fifth larval stage.

(Pl. II, figs. 1 & 2).

This stage is rather sharply marked off from the preceding one, a complete exuviation of the larva having taken place, whereby both the carapace and the lateral pedal buds now become freely exposed.

The carapace has somewhat increased in size, covering a greater part of the trunk, and advancing over the anterior pair of pedal buds, its posterior emargination having at the same time become distinctly angular.

The furcal processes have likewise increased in length,

Trykt den 6te Juni 1896.

and exhibit each at the base dorsally a small secondary denticle not found in the previous stages. This denticle represents the strong, spiniform inferior corner of the tail-plates in the adult animal, whereas the terminal part of the furcal processes becomes converted into the caudal claws.

In this stage, moreover, the first trace of the compound eye is seen above and somewhat in front of the ocellus. It appears as 2 widely separated, and very small pigmentary patches, each surrounded by a pellucid area, in which the visual elements are in process of development. This organ in the larva is accordingly double, whereas in the adult animal the 2 halves are so completely fused together as to constitute a simple mass.

Finally, in this stage another organ has made its first appearance, viz., the heart, which is rather distinctly traceable in the anterior part of the trunk dorsally (see fig. 1), exhibiting already some irregular pulsations.

In the structure of the Nauplian limbs, no perceptible change has taken place, and the larva moves through the water in the very same manner as in the previous stages.

The length of the larva in this stage has increased to 0,52 mm.

Sixth larval stage.

(Pl. II, figs. 3, 4, 5).

This stage is chiefly distinguished by the progressive development of the carapace and of the branchial legs; otherwise it nearly agrees with the preceding one, no exuviation having apparently taken place between the two.

The carapace has now considerably increased in size, and is rather broad and expanded, obtecting, like a mantle, the dorsal face of the trunk in more than half its length. The lateral parts are of rounded form, and advance over the greater part of the developing legs. Dorsally, they still pass immediately into each other, but posteriorly they are separated by a deep incision. Anteriorly the carapace is also well defined, and between it and the anterior division of the body a rather deep impression occurs (see fig. 3). The shell-gland is best seen in the lateral view of the larva (fig. 3), and has nearly assumed its definitive structure.

The anterior, or cephalic part of the body is scarcely half as long as the posterior, and has the dorsal face still strongly convex above. In a lateral view of the larva (fig. 3), it appears almost transversely truncated in front, with the anterior edge somewhat flexuous, exhibiting a slight bulging at the place inside which the compound eye is developing. The lower corner, in front of the antennulæ, is somewhat projecting, but no trace of a true rostrum is as yet to be detected. The posterior division, as in the preceding stages, is gradually narrowed distally, and has the furcal processes more fully developed, with the secondary denticle larger. At some distance in front of the latter is seen dorsally a slight angular prominence, and below it the caudal setæ are about to grow forth.

The ocellus, labrum and Nauplian limbs are, on the whole, unchanged, except that the outer ramus of the antennæ exhibits a trace of an articulation.

The branchial legs, of which, in the preceding stage, only 4 pairs of bud-like rudiments were found, appear now more fully developed. They have, moreover, increased to 6 pairs, rapidly diminishing in size posteriorly, the last pair being still rather small. On all the legs the 3 chief parts, the exopodite, endopodite and epipodite, may now be discerned, and small bristles are already seen growing forth from the tip and inner edge of the endopodites. The coxal lobes are likewise well defined, and easily observed, when the larva is viewed from the ventral face (fig. 5), all of them curving inwards. Still, however, the legs are quite immovable and densely crowded, all pointing behind. The length of the larva has now increased to 0,65 mm.

This is the last larval stage, and the young animal is now about to cast its skin, before entering into the next phase of its development, the postlarval one.

II. Postlarval stages.

The postlarval development is of very long duration, as compared with the larval one, and indeed rather more than a month would seem to be needed for its full accomplishment. It comprises numerous succeeding stages, each being marked off by an exuviation of the animal, whereby, however, only the inner coating of the shell is cast off, the valves being kept in their place, and only supplied with a newly-formed peripheric area. In this manner the characteristic, concentrical lines of growth are formed, the number of which indeed indicates the number of successive exuviations, which have taken place. Among the most prominent features distinguishing this phace of the development from the larval one, may be mentioned, besides the transformation of the mantle-like carapace of the larva into a true bivalve shell, the complete loss of both the masticatory processes of the antennæ and of the mandibular feet, and finally, the functional evolution of the branchial legs.

As the postlarval development on the whole proceeds rather gradually, without any strongly marked changes, only some few stages need be described in detail.

First postlarval stage.

(Pl. III, fig. 1).

Though this stage immediately succeeds the last larval one, being only marked off from it by a single exuviation, very considerable changes have taken place in the organisation of the animal, which now presents itself under a rather different appearance. Whereas in the larval stages, owing to the lateral extension of the antennæ and mandibular feet, the animal, when brought under the microscope in a small quantity of water, invariably turns its dorsal or ventral face to the observer, it is now found to assume a lateral attitude, it being rather difficult to get a dorsal or ventral view of the animal. This is chiefly due to the transformation of the carapace, as also to a somewhat different direction of the antennæ. On the whole, the animal now exhibits a more compressed form, whereas in the larval stages it looks on the contrary somewhat depressed. Of exclusively larval organs some remnants are still found, though in process of degeneration. Thus the antennæ exhibit at the base posteriorly a conical projection, not found in the succeeding stages. This projection is the rudiment of the peculiar bifurcate masticatory process, mentioned in the larva as a most efficient auxiliary organ for alimentation. Moreover, a rudiment of the mandibular feet is still found appended to the outer side of the mandibles, but both these appendages are now quite useless, and have therefore lost their bristles, being also greatly reduced in size.

The carapace has now been transformed into a distinctly bivalvular shell, obtecting the trunk not only dorsally but also laterally, so as to include between the valves both the oral parts and the legs. It is, however, still of inconsiderable size, as compared with that in the adult animal, for which reason, the anterior and posterior parts of the body remain uncovered, projecting considerably beyond it, without being enabled to withdraw themselves into the shell. Seen laterally, it exhibits a rounded triangular form, its antero-dorsal corner being somewhat projecting. The dorsal edge, where the valves are connected, appears rather short and nearly straight, joining the free posterior edges of the valves at an obtuse angle. In the anterior part of each valve the shell-gland may be very distinctly traced as an oval coil of closely crowded canals. Otherwise the shell is quite smooth, without any trace of concentric lines, and highly pellucid.

The anterior, or cephalic part of the body is still strongly convex above, and is defined dorsally from the adjoining part of the trunk by a distinct, though not very deep depression, from which a transversal suture passes on each side to the insertion of the mandibles. The frontal part of the head is now produced downwards to a distinct, though not very prominent, acute rostrum, and has the anterior edge somewhat irregularly flexuous. Ventrally, the head is prolonged into the posteriorly pointing labrum, the form of which now nearly agrees with that in the adult animal, being somewhat compressed, not, as in the larval stages, shield-like.

The compound eye is still double, and has the pigment rather poorly developed, the visual elements being not yet distinctly formed. On the other hand, the ocellus, located at some distance below the eye, is very conspicuous, and exhibits much the same appearance as in the larval stages.

The antennulæ, issuing from the ventral face of the head in front of the labrum, are well defined, though still rather short and claviform in shape, without any trace of segmentation or lateral lobules.

The antennæ exhibit a structure somewhat intermediate between that in the larvæ, and that characteristic of the adult animal. As in the latter, the scape is bent anteriorly, exhibiting an almost elbow-shaped flexure at the base, and from this flexure the above-mentioned rudiment of the masticatory process is seen to issue. At the end the scape exhibits several imperfectly defined joints, not found in the larva, and from the anterior side of them several small, spine-like bristles are seen growing forth. Posteriorly a single, rather short, ciliated bristle occurs, which is easily recognized as the remnant of the strong, falcate seta originating from the same place in the larva. This bristle becomes subsequently lost altogether, as also the basal process, which latter becomes replaced by a bundle of ciliated setæ. The rami are still rather short, though somewhat more fully developed than in the larva. The outer ramus is the larger, and is divided into 5 or 6 articulations, the 2 middle of which have each anteriorly a single short spine. The last articulation has a similar spine and 2 ciliated setæ, and each of the 3 preceding articulations a somewhat longer seta posteriorly. The number of natatory setæ on this ramus is accordingly the very same as in the larva. The inner ramus has retained its original simple cylindric form, though a slight trace of segmentation is visible in the middle; and it carries only 3 apical setæ, the 4th seta occurring in the larva being replaced by a very small dentiform projection.

The branchial legs are now so fully developed, as to admit of being moved in the rhythmical manner characteristic of the adult animal. Behind the 6 pairs already found in the last larval stage, 2 additional pairs have developed, the total number of legs being accordingly 8 pairs.

The pedigerous part of the trunk in this stage shows the first trace of segmentation, and from the segments the dorsal, hairy protuberances are seen growing forth, their number being, in this stage, only 4.

The caudal part, or tail, is still but little deflexed, and thereby less conspicuously marked off from the adjoining part of the trunk. It is, however, constructed in essentially the same manner as in the adult animal, the caudal claws being now well defined and movably articulated to the anterior corner. Each of the caudal plates is produced at the lower corner to a strong spiniform projection, and between this projection and the knobs carrying the caudal setæ, only a single denticle is as yet developed on each plate. Just above the caudal setæ, as in the adult animal, a pair of dentiform projections occur, and in front of them there are traces of another pair.

Of the inner organs, the alimentary tube is very conspicuous by its yellow contents which turn to dark brown in its posterior part. Anteriorly, it has on each side a well-defined cæcal appendage, which is slightly bilobed and forms the commencement of the liver. The heart is also distinctly observable within the anterior part of the trunk dorsally. It is rather elongated, and exhibits on each side 4 venous fissures.

The body is still highly transparent and almost colourless. Its length, measured from the tip of the rostrum to the end of the caudal claws, is 0,65 mm, or about the same as in the last larval stage. The length of the shell scarcely exceeds 0,40 mm.

As to the mode in which the animal moves through the water, it looks very different from that observed in the larva. Whereas in the latter, by rhythmical and not very rapid strokes of the antennæ, and partly also of the mandibular feet, a rather slow and somewhat jumping motion is effected, it has now more the character of an even run, the animal being propelled by very rapid strokes of the outer part of the antennæ alone. At times the animal is also seen affixing itself with its back to the walls of the aquarium, but both in this case and during swimming, the branchial legs are found to be in an uninterrupted swinging motion.

Second postlarval stage.

(Pl. III, fig. 2).

This stage is chiefly characterized by the appearence on the shell of the 1st line of growth. This line is nothing less than the edges of the primitive valves, which, as it were, are superposed on the newly formed ones, so as to leave only the peripheric part of the latter exposed. This part is rather narrow, and has the edges throughout fringed with delicate bristles, not found on the edges of the primitive valves. By the said additional peripheric area, the shell has increased considerably in size, so as now to allow the animal, by a strong flexion of its anterior and posterior parts, to be completely withdrawn into the shell. Its form is, however, nearly unaltered.

As to the animal, the rostral part of the head has become considerably produced, terminating in a very acute point, whereas its dorsal part is somewhat less convex than in the preceding stage.

The compound eye is more fully developed, and its 2 halves are about to join in the middle.

The antennulæ are still rather short and claviform.

The antennæ have quite lost the basal process, as also the seta found in the preceding stage at the end of the scape posteriorly, whereas the spine-like bristles in front are more fully developed. The rami are now subequal in length, the outer one resembling that in the preceding stage, except that the 2 middle joints have each 2 spines, instead of a single one, anteriorly. The inner ramus is divided into 5 well-defined articulations and, like the outer, is provided with scattered natatory setæ, both at the tip and on the posterior edge.

The number of branchial legs is apparently the same as in the preceding stage, though perhaps a 9th pair is in process of formation. The pedigerous part of the trunk is more distinctly segmented, and the hairy dorsal protuberances have considerably increased in number.

The tail appears more deflexed, but otherwise exhibits an appearance very similar to that found in the preceding stage.

The length of the shell in this stage measures 0,70 mm, its height being 0,56 mm.

Third postlarval stage.

In this stage, which is not figured in the plates, 2 lines of growth have appeared on the shell, which has thereby increased considerably in size, measuring now 0,86 mm. in length. The enclosed animal does not much differ from that in the preceding stage, and is still highly pellucid, with only a very faint yellowish tinge, the shell being, as in that stage, almost colourless.

Fourth postlarval stage.

(Pl. III, fig. 3).

The shell in this stage masures 0,93 mm., and exhibits 3 lines of growth, the outer 2 being, like the free edges ot the valves, fringed with delicate bristles. Its form has become somewhat more elongated in proportion to its height, but is still rather unlike that of the adult animal.

Of the several appendages, the antennulæ have somewhat increased in length, but are still quite simple, without any distinct segmentation or lateral lobules. The rami of the antennæ have likewise become more elongated, and are each divided into 7 well-defined joints. Of branchial legs, 10 pairs are now distinctly developed, and on the caudal plates 3 denticles have appeared above the spiniform lower corners.

As to the inner organs, it is only to be noted, that the cæcal appendages of the intestine have commenced to divide in a dichotomic manner, to form the complicated liver-masses filling up, in the adult animal, a great part of the inner cavity of the head.

Seventh postlarval stage.

(Pl. IV, fig. 1).

In this stage the shell exhibits 5 well defined lines ot growth, and measures in length 1,70 mm. The primitive valves now occupy only a comparatively small part of the shell, and their edges, forming the 1st line of growth, are concentrically encompassed by the 4 other lines, which all, like the free edges of the valves, are densely setiferous. The form of the shell is still somewhat more elongated than in the 4th stage, more approaching that in the adult animal, though the umbonal part appears far less prominent.

The enclosed animal (not drawn in the figure), which now exhibits a clear yellowish orange hue, has developed its appendages more fully, the antennulæ being considerably more elongated, and each of the rami of the antennæ having become 8-articulate. The branchial legs have increased in number, 12 pairs being now distinctly developed, and behind them there is, moreover, a slight trace of 2 other pairs in process of formation. The tail does not differ from that in the preceding stages, except by a somewhat increased number of denticles on the concave edge of the terminal plates. The cæcal appendages of the intestine have now divided into numerous lobes, and exhibit a clear yellowish hue.

Ninth postlarval stage.

(Pl. IV, fig. 2).

The length of the shell in this stage has increased to 2,25 mm., the height being 1,55 mm., and its form is now rather similar to that of the adult animal, though somewhat more compressed. The lines of growth are 8 in each valve, being all, except the 1st, like the free edges of the valves, fringed with bristles, which, however, are shorter and more densely crowded than in the stages previously described. The 1st line of growth now only encompasses a very small part of the shell, and it is easily seen that the primitive valves become at last restricted to the tip of the umbones, where, on a closer examination, they can be discerned even in full-grown specimens.

The enclosed animai (not dravn in the figure) has now assumed a light brownish hue, but is still rather transparent, so as to admit of the alimentary tube being very distinctly traced in its whole length. Also the shell-gland, which in the adult animal is very difficult to observe, appears rather distinctly inside the umbonal part of the valves. Of branchial legs may now easily be counted 16 pairs, and behind them some other pairs are apparently in process of formation.

Subsequent postlarval stages.

The succeeding stages, which are rather numerous, I do not find it neccessary to describe in detail. They are characterized by a very gradual increase both of the shell and animal, the lines of growth at the same time augmenting in number, and the several appendages assuming gradually the appearance characteristic of the adult animal. In most of the stages the setous armature of the lines of growth and of the free edges of the valves could be discerned; but the bristles gradually become shorter and partly broken off, so as at last, for the most part, only to leave their insertions. The peculiar radiating striation of the shell described in my previous paper, is undoubtedly due to these bristles, or more correctly to their former insertions on the edges of the several superposed valves.

III. Adult form.

(Pl. VI, figs. 3 & 4).

The full-grown animal of both sexes has been described in detail by the author in his previous paper, from alcoholic specimens. I shall therefore here only give some notes on the colouring and the habits of the animal, as observed in my aquaria, and add 2 figures of the largest specimen reared, representing the animal within its shell viewed from the side and from above, in the attitude it generally assumes when brought under the microscope in a suitable quantity of water.

The specimen, which was of the female sex, measured in length about 7 mm., and may be supposed to have attained its full size, as the lines of growth were no less than 24 on each valve, or as many as in the largest specimen formerly examined. The shell was horn-coloured and semi-transparent, whereas the enclosed animal exhibited a very dark brownish red colour, turning, on the ventral face and on the legs, to a vivid and deep blood-red. The alimentary canal could be only faintly traced through the shell, and on its sides the greatly developed, opaque whitish ovaria could be discerned, in the form of elongated, twisted bags (see fig. 3).

As to habits, the animal showed itself to be on the whole rather sluggish, being often found for a rather long time resting on the very same place, more or less deeply burried within the loose bottom deposit. At times, however, and especially in clear weather, it made some abrupt excursions through the water, moving rather rapidly, and at a perfectly even rate up along the walls of the aquarium, sometimes up to the surface of the water; but it very soon sank back to the bottom, assuming again its quiet attitude. The movements, as in other bivalve Phyllopoda, seem to be exclusively effected by the aid of the antennæ, the outer part of which, together with the head, being extruded from the shell anteriorly, and the rami violently moved sidewards. Not infrequetly the animal was seen to move in this manner rather slowly along the bottom, the back upwards, whereby the muddy particles were whirled up around it and partly thrown inside the shell. This proceeding being often repeated, it would seem that it was effected chiefly for the purpose of feeding.

In the same aquarium, in which the above-mentioned female specimen occurred, two male specimens were also reared, both apparently attaining to their full size, though being somewhat smaller than the female. They were often seen eagerly pursuing the female, and in one case one of the males got a rather firm hold on the female by inserting the strong claws of his 2 anterior pairs of legs inside the shell of the latter, at its upper posterior corner. The 2 sexes remained for rather a long time locked together in this manner, but wether a true copulation thereby took place, I could not ascertain. The specimens, after having been subjected, to a closer examination under the microscope, were replaced in the aquarium, but they did not live long afterwards, and their empty shells were subsequently found on the bottom of the aquarium

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Explanation of the plates.

Pl. I.

Fig. 1. Recently hatched larva (1st larval stage), viewed from the dorsal face; magnified 120 diameters.

Fig. 2. Same, ventral view.
» 3. Larva in the 2nd stage, viewed from above; × 120.
» 4. Same, ventral view.
» 5. Larva in the 3rd stage, viewed from the ventral face; × 120.
» 6. Larva in the 4th stage, viewed from above (left antenna and mandibular foot not fully drawn) × 120.
» 7. Same, ventral view.

Pl. II.

Fig. 1. Larva in the 5th stage, viewed from above (left antenna and mandibular foot not fully drawn); × 120.
» 2. Same, ventral view,
» 3. Larva in the 6th or last stage, viewed from the right side; × 120.
» 4. Somewhat more advanced larva of same stage viewed from above (left antenna and mandibular foot not fully drawn); + 120.
» 5. Same, ventral view.

Pl. III.

Fig. 1. Young Estheria in the 1st postlarval stage, viewed; from left side; magnified 120 diameters.
» 2. A specimen in the 2nd postlarval stage, the shell having acquired the 1st line of growth, viewed from right side; magnified 95 diameters.
» 3. Another specimen in the 4th postlarval stage, with 3 lines of growth, exhibited from right side; × 80.

Pl. IV.

Fig. 1. Shell of a young Estheria in the 6th postlarval stage, with 5 lines of growth, viewed from left side; × 42.

» 2. Shell of another specimen in the 9th postlarval stage, with 8 lines of growth, viewed from left side; × 32.

» 3. Fully grown female, drawn from life, and viewed from left side, magnified about 10 diameters.

» 4. Same, dorsal view.

ON FRESH-WATER

ENTOMOSTRACA

FROM THE NEIGHBOURHOOD OF SYDNEY,

PARTLY RAISED FROM DRIED MUD.

BY

G. O. SARS

WITH 8 AUTOGRAPHIC PLATES

KRISTIANIA
ALB. CAMMERMEYERS FORLAG
(LARS SWANSTRØM).

KRISTIANIA — CENTRALTRYKKERIET 1896.

INTRODUCTION.

As is well known, our earliest knowledge of Australian fresh-water Entomostraca is due to the Rev. R. L. King, who in the «Papers and Proceedings of the Royal Society of Van Diemen's Land» has published some interesting treatises on that part of the fauna. His investigations were chiefly restricted to the environs of Sydney, and showed indeed that part of the country to be rather rich in Entomostraca, some of which exhibited a very close relationship to well-known European species, though the greater number of them were regarded as specifically distinct. As the descriptions and figures given by Mr. King do not always admit of our fully recognizing the species, I was very anxious to obtain some of the native forms for a closer examinination, and for this purpose applied to two well-known naturalists of the country, Prof. Ramsay and Mr. Th. Whitelegge. Both these gentlemen readily complied with my request, and furnished me with a rather interesting material, the working out of which has been of great interest to me. In 1888, Prof. Ramsay kindly sent me a tube containing a sample taken from the Waterloo swamps near Sydney, and in the succeeding year, I published in the Transactions of the Scientific Society of Christiania a short account of the contents of the tube. Some years afterwards, several additional samples preserved in spirit were kindly forwarded to me by Mr. Whitelegge, who collected them from several places in the neighbourhood of Sydney, and recently a number of samples of dried mud have also been kindly sent to me by the same gentleman. With this mud I have made, in the course of the past summer, a series of hatching experiments, and have thereby been enabled to examine the greater part of the species also in the living state. Of the Phyllopoda I have already in this Journal given a detailed account accompanied by autographic plates, and propose now to give a similar account of the other Entomostraca. The number of species examined amounts to no less than 42 in all, 26 of which have been examined in the living state. As several of these species have already been described and figured in detail by the auther in previous papers, some from the northern part of the country, some from New Zealand, these forms will be only briefly mentioned in the present paper, whereas descriptions and figures will be given of the remaining species.

The plates accompanying this paper have been prepared with the greatest care by the autographic process, and I am glad to see that the printing of the plates has been more successfully accomplished than has been the case with the plates of some of my recent papers.

Cladocera.

Fam. Daphnidæ.

Gen. **Daphnia**, Müller.

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1. Daphina carinata, King.
(Pl. 1.)

Daphnia carinata, King, Papers & Proceedings Roy. Soc. Van Diemen's Land, Vol. II, Part. II, p. 246, Pl. I, p. 253, Pl. VI. A.

Specific Characters.—♀ Shell, seen laterally, somewhat varying in shape, being in some specimens oblong oval and narrowed posteriorly, in others comparatively broader, rounded quadrangular, spine generally rather long and more or less obliquely upturned, denticles of the dorsal margin extending nearly to the cervical region. Head distinctly carinated throughout, the carina being more or less developed, and thereby causing the lateral aspect of the head to be somewhat variable, though it always appears rounded in front; rostrum acute, not deflexed; fornix terminating on each side in a spiniform corner. Eye of moderate size. Antennulæ very small, scarcely projecting beyond the shell of the head. Tail conically tapering, with the posterior edge perfectly straight, anal denticles about 12 on each side, rather small and subequal; terminal claws comparatively short, without any secondary denticles. Ephippium produced anteriorly to a narrow stripe, egg-ampullæ obliquely disposed. Length, without the spine, from 3 to 4½ mm.

Remarks. The present form, first described by Mr. King, is closely allied to the New Zealand species *D. Thomsoni*, G. O. Sars, though differing in some particulars, so that it should more properly be regarded as specifically distinct. As Mr. King observes, it is, however, a very variable species. The crest of the head, from which the species has been named, seems indeed to vary considerably in development, thereby giving the head a somewhat different appearance in specimens from different localities, as shown in the figures here given. Mr. King has figured a very extreme variety, in which the crest even forms a strongly curved lamina projecting from the cervical region. The shape of the shell itself would also seem to be subject to some variableness, according to locality, perhaps also according to the season. Notwithstanding this great variableness, there are to be found certain characters common to all the varieties, by which this species may be readily distinguished from the New Zealand form. Thus the rostrum is never, as in that form, deflexed, but forms always the immediate continuation, of the ventral edge of the head. The shell-spine in all the individuals I have examined, is considerably longer than in *D. Thomsoni*, and, as a rule, also more upturned. Moreover, the denticles of the dorsal margin of the shell are continued in front as far as the cervical region, whereas in the New Zealand form they are restricted to the posterior half only of this margin. Finally, the tail is more regularly conical in form, and the terminal claws comparatively much shorter.

Description of the female.

a. *Typical form.*
(Pl. 1, figs. 1, 2).

This form, or variety, agrees closely with that described and figured by Mr. King as the «common form», and is probably derived from the very same locality as the latter.

The length of the largest specimens examined measures, without the spine, 4,70 mm.; but the greater number of the specimens are considerably smaller, though ovigerous.

The form of the shell, when seen laterally (fig. 1), is oblong oval, and considerably narrowed posteriorly towards the base of the spine, with the dorsal margin evenly convex in the middle, and forming anteriorly, in the cervical region, a very slight concavity. The spine, which issues from near the middle of the posterior extremity, is rather elongated, exceeding half the length of the shell, and is perfectly straight, but somewhat upturned.

The head appears considerably narrower than the shell, and somewhat irregularly rounded in front, with a slight indication of an angle in the ocular region. Its ventral edge is somewhat oblique, and forms a perfectly straight line as far as the tip of the rostrum, which is accordingly not deflexed, though terminating in a very acute point. The dorsal crest, the limits of which are shown by the insertion of the muscles moving the antennæ, is not very largely developed, though distinct all round the head. The fornix appears, in the lateral view of the animal, as a curved elevated line extending from the ocular region to the point where the valves take their origin, and in this place projecting as a spiniform corner. The posterior half of the free edges of the valves is closely denticulated, the denticles being continued, as usual, along the lower edge of the shell-spine to its tip. The spine, moreover, exhibits 2 lateral and one dorsal row of similar denticles, the dorsal row being continued in front along the dorsal margin of the shell as far as the cervical region. The sculpture of the shell is the usual one, consisting of 2 sets of curved striæ crossing each other at nearly right angles.

The eye is of moderate size, and placed somewhat within the anterior edge of the head, at its junction with the ventral one. It exhibits a number of distinct crystalline bodies projecting from the dark pigment. The ocellus is extremely minute, punctiform, and located at some distance behind the eye, at the inferior end of the cerebral ganglion.

The antennulæ, as in *D. Thomsoni*, are very small, and scarcely project beyond the shell of the head, except with their apical bundle of olfactory papillæ.

The antennæ are constructed in the usual manner, and have the natatory setæ densely plumose.

The tail exhibits dorsally the usual curved lappets, and has the terminal part (see fig. 2) comparatively short and conically tapering distally, with the posterior edge perfectly straight and densely hairy in its upper part. The anal denticles are rather small and of uniform length, about 12 on each side. The terminal claws are comparatively much shorter and stouter than in *D. Thomsoni*, and are destitute of any trace of secondary denticles, though a delicate ciliation may be observed along their concave edge.

The cæcal appendages of the intestine are of moderate size, and but slightly sigmoid.

The ova in the matrix, in large specimens, are very numerous and of comparatively small size.

b. *Var. intermedia.*

(Fig. 3).

In this variety, which is of somewhat smaller size, measuring in length, without the spine, 3,35 mm., the head appears comparatively larger in proportion to the shell, with the dorsal crest more developed. The shell is less narrowed posteriorly, and the spine issues considerably above the longitudinal axis, being obliquely upturned.

All the specimens of this variety, which I have had an opportunity of examining, were provided with ephippia, and accordingly belonged to the later generations.

The ephippium is rather narrow and, seen laterally, of a somewhat fusiform outline, with the anterior extremity prolonged into a narrow stripe extending along the cervical part of the shell and, like the whole dorsal margin, densely denticulated. The egg-ampullæ are rather small and obliquely disposed, exhibiting a very dark hue, whereas the remaining part of the ephippium is opaque whitish.

c. *Var. magniceps.*

(Fig. 4).

This variety, which attains a length, without the spine, of $3^1/_2$ mm., differs considerably in its outward appearance from the two preceding ones, though evidently belonging to the same species. The shell is comparatively shorter and broader, and exhibits a rounded quadrangular form, with the dorsal margin nearly straight, and not defined from the head by any perceptible sinus. The spine, which issues far above the longitudinal axis, is considerably upturned, and about half the length of the shell. The head is exceedingly large, fully as broad as the shell, and has the dorsal crest strongly developed, its inner limit being well indicated by the insertion of the antennal muscles. The edge of the head forms a quite even and uninterrupted curve from the cervical region to the tip of the rostrum. The specimens examined were laden with numerous small eggs in the matrix, and would accordingly seem to have belonged to the earlier generations. In the structure of the fornix, tail and various appendages, no differences could be detected between this and the 2 preceding varieties.

Observations. Some few specimens of the present species were successfully hatched in my aquaria from the mud received, but none of them arrived at full maturity, apparently owing to the excessive increase in the same aquaria of another form, a species of Moina. I am therefore not able to say into which variety these specimens would have developed. The specimens, which had the spine of the shell very much elongated and somewhat upwards curved, were watched for some time in the aquaria. They kept themselves constantly near the bottom, moving along it in the usual somewhat jumping manner.

Occurrence. According to Mr. King, the present species is rather common in the environs of Sydney. The localities for the typical form are not enumerated, whereas for the 4 varieties he figures, none of which agrees with thoes here described, the localities were recorded. Of the typical form several well-preserved specimens were contained in the sample first sent me for examination by Prof. Ramsay. This sample was taken on the 13th August, 1888, from the Waterloo swamps. The variety *intermedia* was found in a sample taken by Mr. Lea from some ponds «Near Hay». Finally, the variety *magniceps* occurred, though rather sparsely, in a sample taken by Mr. Whitelegge from Waterholes off Bourke Street, Waterloo. Out of the continent of Australia, this species has as yet not been recorded.

Gen. **Simocephalus**, Schoedeler.

2. Simocephalus australiensis (Dana).

Daphnia australiensis, Dana, United St. Expl. Exp. Crust. II, p. 1271, Pl. 89, figs. 4, a—e.

Simocephalus australiensis, G. O. Sars, Addit. Notes on Austral. Cladocera raised from dried mud, p. 15, Pl. 2, figs. 1—5.

Of this form, described and figured in detail by the author in the above mentioned paper, some specimens were collected by Mr. Whitelegge from the Marubra Swamp near Sydney.

Distribution. Queensland, Knysna (G. O. Sars).

3. Simocephalus Elisabethæ (King).

Daphnia Elisabethæ, King. l. c. p. 247, Pl. II.

Simocephalus Elisabethæ, G. O. Sars, l. c. p. 22, Pl. 2, figs. 6, 7.

As pointed out in my above mentioned paper, Mr. King has most probably confounded this and the preceding species. It is therefore not possible to decide with certainty the localities where the present species was found by that author. A few not very well preserved specimens of this form were found in one of the samples sent me by Mr. Whitelegge. It was taken from a pond off Botany Road, near Waterworks Bridge, on the 6th April. 1895.

Distribution. Queensland (G. O. Sars).

4. Simocephalus acutirostratus, (King).

(Pl. 2, figs, 1—3).

Daphnia Elisabethæ, var. *acutirostrata,* King, l. c. p. 254, Pl. VI, C.

Specific Characters. Shell, seen laterally, oblong oval, terminating posteriorly in a rather prominent, obtusely conical prominence, slightly denticulated at the tip, and extending somewhat above the longitudinal axis, dorsal margin forming a perfectly even curve throughout. Head comparatively small, procumbent, with the front produced into an acute deflexed projection, ventral edge straight, obliquely ascending, rostral projection small, deflexed. Eye of moderate size; ocellus very small, punctiform. Tail rather broad, forming, above the anal sinus, a gibbous expansion, anal denticles about 12 on each side, terminal claws with a series of well-marked secondary teeth. Length attaining 3 mm.

Remarks. This form has been recorded by Mr. King as only a variety of his *Daphnia Elisabethæ.* It is, however, quite certainly, as justly pointed out by Mr. Schoedeler, a very distinct species, exhibiting, as it does, several well-marked differences from all the other known species of the genus. The specific name *acutirostratus* is somewhat inappropriate, since it is not the rostrum, but the front, which is acutely produced. According to the laws of priority, however, this name, as the older one, must be preferred to that proposed by Schoedeler, viz., *paradoxus.*

Description of the female.

The length of the largest specimens examined is about 3 mm., and this form accordingly grows to a rather large size, as compared with the other species of the genus.

The shell, as in the other species, is rather tumid, and somewhat navicular in shape. Seen laterally (fig. 1), it exhibits an irregular oval, or oblong sub-rhomboidal form, with the posterior extremity remarkably produced, and forming a rather large, obtusely conical prominence extending somewhat above the longitudinal axis of the body. The prominence is not defined above by any distinct sinus, and exhibits at the tip a number of small appressed denticles. The dorsal margin of the shell is quite evenly convex throughout, and continuous with that of the head, though, as usual, a small indentation may be traced between the two in the cervical region. The inferior edges of the valves are greatly bulging in front, and posteriorly join the obliquely ascending posterior edges by an even curve.

The head (see also fig. 2) is comparatively small and procumbent, and is highly distinctive by the production of the front into a very conspicuous acute, deflexed projection, resembling a rostrum. Behind the latter, the ventral edge ascends obliquely and quite evenly to the small, deflexed, true rostrum. The fornix is moderately prominent, and of the usual appearance, joining the valvular part of the shell at a very acute angle.

The shell is sculptured in the usual manner by oblique, partly anastomosing striæ, running parallel to the posterior edges; and exhibits inside, at some distance from the inferior edges, a ciliated ridge.

The eye (see fig. 2) is not very large, and exhibits a number of well-defined crystalline bodies projecting from the dark pigment.

The ocellus (ibid.) is very small, punctiform, and occurs near the insertion of the antennulæ.

The latter appendages (ibid.) exhibit the usual structure, and this is also the case with the antennæ (see fig. 1).

The tail (fig. 3) is remarkably broad, and differs from that in other species by the production of the posterior edge, above the anal sinus, to a nearly rectangular gibbous expansion. The anal sinus itself is defined above by a rather small, obtusangular corner, and is armed on each side with about 12 denticles, successively rapidly increasing in length distally. The terminal claws are nearly straight, and each armed in their basal part with a regular, comb-like series of well-marked secondary teeth.

The number of eggs in the matrix is often very great, amounting to more than 50 in all.

Young specimens have the acute projection of the front as distinct as in the adults, and only differ in their smaller size, and in the dorsal margin of the shell not being convex, but nearly straight.

Occurrence.—Mr. King found this form in ponds at Denham Court. In one of the gatherings kindly sent me by Mr. Whitelegge, and taken from Waterholes at Bourke Street, this species occurred rather abundantly, and it was also found in another sample probably from the same locality.

Though some ephippia apparently of this form were detected in the mud sent me from the said place, I did not succeed in hatching this form in my aquaria. As, however, the spirit-specimens sent were in a very good state of preservation, a minute examination could be instituted, especially by mounting the specimens in canada balsam, whereby a sufficient transparency of the body could be obtained.

5. Simocephalus gibbosus, G. O. Sars, n. sp.
(Pl. 2, figs. 4—6).

Specific Characters.—♀ Shell, seen laterally, obliquely oval, widening posteriorly, and terminating with a comparatively short and blunt median prominence; dorsal margin for the greater part of its length, almost straight, posteriorly, however, abruptly curved, forming a large and very conspicuous, gibbous expansion just above the median prominence, edges of the expansion closely denticulated. Head of moderate size, less procumbent than in the preceding species, front narrowly rounded, ventral edge scarcely ascending, and slightly convex in the middle, rostral projection almost obsolete. Eye comparatively larger than in the preceding species; ocellus prolonged anteriorly into a narrow stripe. Tail less broad, posterior edge above the anal sinus scarcely expanded; anal denticles 10—12 on each side; terminal claws quite smooth. Length of adult female 2 mm.

Remarks.—This new species is allied to the European *S. vetulus*, and has a similarly formed ocellus, but is at once distinguished by the very conspicuous gibbous expansion of the dorsal face posteriorly, which gives the shell a peculiar oblique shape. This expansion is even traceable in quite young specimens.

Description of the female.

The length of fully adult, ovigerous specimens does not exceed 2 mm., and this form is accordingly rather inferior in size to the preceding one.

Trykt den 9de Juni 1896.

Seen laterally (fig. 4), the shell exhibits a somewhat irregular, obliquely oval form, being gradually expanded posteriorly, and terminates in a well-defined, though rather short and blunt prominence, which extends in the direction of the longitudinal axis of the body. The dorsal margin appears, throughout the greater part of its length, almost straight; but quite posteriorly it makes an abrupt bend, so as to form here a greatly projecting gibbous expansion, extending just above the median prominence, and defined from it by a well-marked sinus. The edge of the expansion is coarsely denticulated, the denticles being also continued around the median prominence The inferior edges of the valves appear somewhat less bulging in front, and join the oblique posterior edges by a greater curve.

The head (see also fig. 5) is comparatively larger than in the preceding species, and less procumbent, being, as usual, defined from the shell above by a small indentation. Its dorsal margin is slightly curved, and joins the ventral edges immediately, without any intervening frontal projection, the front itself being narrowly rounded. The ventral edge is slightly convex in the middle, and scarcely ascending, and the rostral projection is rather indistinct, and not, as usual, deflexed. The fornix exhibits the usual appearance.

The eye (see fig. 5) is comparatively somewhat larger than in the preceding species, and located just within the front.

The ocellus (ibid.) exhibits an appearance similar to that found in *S. Elisabethæ,* and in the European species *S. vetulus,* being drawn out in front to a narrow stripe.

The tail (fig. 6) is not nearly so broad as in *S. acutirostratus,* the posterior edge above the anal sinus not being, as in that species, gibbously expanded, but only very slightly convex. The defining upper corner of the anal sinus is, on the other hand, more prominent and nearly rectangular. The anal denticles are 10--12 on each side, increasing, as usual, rapidly in length distally. The terminal claws are perfectly smooth, without any trace of secondary teeth.

The ova in the matrix are comparatively larger than in the preceding species, though sometimes present in a rather considerable number.

Occurrence.—Of this pretty species a number of specimens were collected by Mr. Whitelegge in the Centennial Park, near Sydney.

Gen. **Moina**, Baird.

6. Moina propinqva, G. O. Sars.

Moina propinqva, G. O. Sars, On some Australian Cladocera raised from dried mud, p. 29, Pl. 5, figs. 4, 5; Pl. 6.

Of this species, which in its general appearance strongly recalls the European *M. braciata,* some few specimens were collected by Mr. Whitelegge from waterholes off Bourke Street.

The same form was also raised in one of my aquaria, from mud derived from the same locality. It did not, however, multiply to nearly such an extent as the 2 succeeding species.

Distribution.—Queensland (G. O. Sars).

7. Moina australiensis, G. O. Sars, n. sp.

(Pl. 3.)

Specific Characters.—Shell of the usual appearance, varying in female considerably in form, according to the degree of distention of the matrix. Head in female not very large, and somewhat procumbent, being evenly vaulted above, with a very slight, though distinct sinus above the eye, front not much produced and obtusely rounded, ventral edge but very slightly convex at the insertion of the antennulæ. Head in male comparatively much larger, sub-erect, and less strongly vaulted above, frontal part obtusely truncated, ventral edge straight. Eye of moderate size. Antennulæ in female comparatively short, subfusiform, in male about the length of the head, and armed at the tip with 4 strong claws. First pair of legs in female with the sub-apical seta simple, ciliated; those in male having, in addition to the usual claw, an unguiform spine and a long terminal seta. Caudal claws quite smooth. Ephippium with 2 egg-ampullæ placed obliquely transversally. Body pellucid, in female with a more or less distinct orange hue. Length of adult female 1,30 mm., of male 0,80 mm.

Remarks.—This form exhibits several points of agreement with the European species *M. paradoxa,* Weismann, and indeed at first I belived it to be the very same species. Being however acquainted with another Australian species, which exhibits a similar agreement, and having instituted a closer comparison between the European species and these 2 Australian forms, I am now induced to regard them as being specifically distinct. From *M. propinqva,* the present species is easily distinguished by the rather different form of the head, the structure of the 1st pair of legs in the male, and by the ephippium having 2, instead of a single egg-ampulla.

Description of the female.

The largest specimens examined attain a length of 1,30 mm., and this form accordingly grows to a somewhat larger size than *M. propinqua*, which, as a rule, does not exceed a length of 1 mm.

The general form of the body (see fig. 1) is that characteristic of the genus, the head being very sharply marked off from the shell by a deep dorsal depression.

The form of the shell appears rather variable, according to the degree of distention of its dorsal part with ova or embryos. Sometimes this part is quite enormously distended, so as to form an almost globular expansion, sharply defined from the valvular part of the shell, and this is generally the case with all the individuals of the earlier generations. The valvular part of the shell, however, preserves its shape unaltered, in all specimens being comparatively small, so as not fully to obtect the tail, a greater part of which is always seen to project freely beyond the shell posteriorly. At the junction between the dorsal and valvular parts, the shell projects posteriorly as a short and obtuse prominence, below which the posterior edges appear slightly incurved. The inferior edges of the valves are nearly straight, and join by a perfectly even curve both the anterior and posterior edges. They are clothed with small marginal hairs, which are more distinct in the anterior part, gradually disappearing behind.

The head is comparatively small and somewhat procumbent without any trace of a dorsal crest, being evenly vaulted above. Just above the ocular region, a slight sinus may be traced, but this sinus is not nearly so pronounced as in *M. propinqva*. The frontal, or ocular part is but slightly prominent, and is evenly rounded; and the ventral edge of the head forms only a slight convexity at the insertion of the antennulæ, without being defined by any perceptible notch from the base of the labrum. Of the fornix, only a slight trace is found as a somewhat elevated ridge above the base of the antennæ.

The eye is of moderate size, and provided with a number of well-defined crystalline bodies. The ocellus, as in the other species of the genus, is wholly absent.

The antennulæ (fig. 2) are comparatively short, scarcely exceeding half the length of the head, and exhibit a somewhat fusiform shape, being distinctly dilated in the middle. They are, as in the other species, freely mobile, and are clothed posteriorly with delicate cilia. Anteriorly each antennula carries a single sensory bristle, occurring somewhat nearer to the base than to the tip, and the latter has a bundle of very small olfactory papillæ.

The antennæ are powerfully developed, and of the structure characteristic of the genus. The scape is very massive and strongly muscular, and is provided near the base outside with 2 juxtaposed and rather long sensory bristles, which, especially in the dorsal or ventral views of the animal, are very conspicuous; at the end, another sensory bristle is seen projecting between the bases of the rami. Both the outer part of the scape and the rami are densely hairy, and the natatory setæ finely ciliated.

The 1st pair of legs (fig. 3) are constructed in the very same manner as in the European species, *M. brachiata,* and differ markedly from those in *M. paradoxa,* by the subapical seta being quite simple and finely ciliated, like most of the other setæ, whereas in *M. paradoxa,* according to the statement of Prof. Weissmann, this seta is very strong, spiniform, and coarsely denticulated anteriorly.

The tail agrees in its structure with that in most other species, its outer part beyond the anal opening (fig. 4) being conically tapered, and provided on each side with 10—12 denticles, the outermost of which is bidentate, whereas the others are extremely delicate, squamiform and finely ciliated on both edges. The terminal claws are perfectly smooth, without any trace of secondary teeth.

The ephippium (fig. 5) is of an oval or somewhat semilunar form, and has the surface very coarsely reticulated. It contains, as in *M. paradoxa*, 2 egg-ampullæ, which are somewhat obliquely disposed, the one behind the other. Before the ephippium is detached from the shell, however, the 2 winter-eggs occupy a rather different place, being, as shown in the succeeding species (see Pl. 4, fig. 2), juxtaposed in the anterior part of the matrix; and in a lateral view of the animal it therefore appears as if only a single ovum were present.

The adult male (figs. 6, 7) is rather inferior in size to the female, scarcely exceeding a length of 0,80 mm., and exhibiting a very different appearance.

The shell is much narrower, its dorsal part not being at all expanded; and the posterior extremity appears, in the lateral view of the animal, obtusely truncated, forming above almost a right angle. The inferior edges of the valves are densely clothed with fine hairs, which, in their anterior part, assume a fur-like appearance.

The head looks very different from that in the female, being much longer and more erect. It gradually tapers towards the front, which appears obtusely truncated and defined above by a very slight sinus. The inferior edge of the head is perfectly straight and horizontal, whereas the upper one is obliquely ascending and, but very slightly convex.

The antennulæ, which issue from the most anterior part of the head, are greatly developed, being fully as long as the head. They are very mobile, but, as a rule, extended obliquely anteriorly, with the terminal part more or less incurved (see fig. 7). Near the base they each form a somewhat genicular bend, and at this place 2 unequal sensory bristles are seen to project anteriorly. The outer part of the antennulæ is rather narrow, and nearly cylindric, and terminates with 4 strongly curved hooks, between which a small bundle of olfactory papillæ is traceable (see fig. 8).

The 1st pair of legs (fig. 9) are, as usual, transformed into powerful grasping organs. They closely resemble in structure those in the male of *M. paradoxa*, as figured by Prof. Weismann, each having a rather long, setiform appendage extending beyond the claw, and terminating in a fine hooked point. In addition, a thin lamella is seen projecting inside the claw, having 3 apical bristles, the anterior of which is curved in a hook-like manner, and devoid of cilia.

The tail does not seem to differ essentially in structure from that in the female.

The testes (see fig 6 & 7) are confined to the posterior part of the trunk, appearing as 2 somewhat twisted bags, which extend along the sides of the intestinal tube. They are each continued into a narrow duct, which enters the tail, and debouches at the sides of the anal orifice. Viewed by a high magnifier (fig. 10), they are found to be filled with clear rounded cells, very densely accumulated in the anterior, dilated part of the bags. It often happens, when a male specimen is examined for any length of time under the microscope, that some of the zoosperms are poured out from the genital openings, and in such cases I have always found them to be simple, rounded, cellular bodies (fig. 11), never showing any approach to the peculiar vermiform shape described by Prof. Weismann in the male of *M. paradoxa*.

In living specimens of both sexes, the body is very pellucid, and in the male almost colourless. In the female, it generally exhibits a more or less distinct orange tinge, and this would seem to be invariably the case with individuals of the earlier generations, whereas those of later generations, as a rule, become more pale in colour.

The «summer-eggs» are at first, when received in the matrix, very small and nearly colourless, with only a very small quantity of nutritive yolk. They, however, rapidly increase in size during the development, imbibing, as first stated by Prof. Leydig, a nourishing fluid contained in the cavity of the matrix, and secreted from a dense cellular layer on the back of the parent animal. The «winter-eggs» are considerably larger, and of a brick-red colour.

Observations.—Of the present form, numerous specimens developed in my aquaria, and in some of them multiplied in quite an astonishing manner, so as at last to fill up the aquaria with myriads of individuals. The earlier generations consisted exclusively of female specimens; but after the lapse of some time, the characteristic ephippial formation was beginning, and at that time male specimens made their appearance in rather large numbers. After the ephippia were deposited, some of the females again became laden with summer-eggs, though generally not in such great numbers as in the individuals of the earlier generations. From that time, the males gradually diminished in numbers, and at last scarcely a single male specimen was to be detected, though the females were still present in great numbers, multiplying in the usual parthenogenetical manner. In some of my aquaria, a 2nd bisexual period was observed, and thereby the «polycyclar» character of this form ascertained.

In habits, this form agrees with the other species of the genus. The movements of the animal are rather rapid, and effected by short abrupt jerks, whereby the body generally assumes a somewhat prone attitude. The males, as usual, are still more agile, and were often seen eagerly to pursue the females. I also happened several times to observe the male getting a rather firm hold of the female, embracing with his powerful antennulæ the lower part of her shell, and at the same time inserting his prehensile 1st pair of legs within the edges of her valves.

Occurrence.—The mud, from which this species was raised, was taken by Mr. Whitelegge from waterholes at Bourke Street, opposite Lachlan Street, and off Botany Road, near Waterworks Bridge. A spirit sample taken from the same localities likewise contained numerous specimens of the same species. Moreover, the greater number of the specimens contained in the sample first received from Prof. Ramsay, and taken from the Waterloo Swamps, turned out, on a closer examination, to belong to the said species.

8. Moina tenuicornis, G. O. Sars, n sp.

(Pl. 4.)

Specific Characters.—Very like the preceding species, but differing rather markedly in the shape of the head, which does not exhibit any trace of a sinus above the eye, and moreover in the female, forms below, at the insertion of the antennulæ, a very conspicuous, rounded prominence, defined from the labrum by a deep notch. Eye comparatively larger than in that species. Antennulæ in female comparatively much longer and narrower, sublinear in form; those in male considerably exceeding half the length of the body. First pair of legs in both sexes of a simular structure to that in the preceding species. Terminal claws of tail armed at the base with a well-marked, comb-like series of secondary teeth. Ephippium with 2 transversely disposed egg-ampullæ. Length of adult female 1,20 mm., of male 0,70 mm.

Remarks.—Though very nearly allied to the preceding species, as also to the European *M. paradoxa,* this form may at once be distinguished from both of them by the form of the head in the female, the remarkably elongated and narrow antennulæ, and finally by the terminal claws of the tail being distinctly denticulated at the base, like those in *M. brachiata*.

Description of the female.

The length of the largest specimens is 1,20 mm., and this form is accordingly but little inferior in size to the preceding one.

The general form of the body (see fig. 1) agrees rather closely with that in *M. australiensis*. On a closer comparison, however, the head is found to differ very markedly in shape, being quite evenly vaulted dorsally, without exhibiting any trace of a sinus above the eye The front is obtusely rounded and, as in the preceding species, but little prominent. On the other hand, the inferior part of the head is produced, at the insertion of the antennulæ, to a rather conspicuous, rounded prominence, which is defined behind by a deep notch, giving the head, in a lateral view of the animal, a physiognomy rather different from that in *M. australiensis*.

In the form and structure of the shell, scarcely any essential difference is to be found from that in the said species, excepting that perhaps the inferior edges of the valves are more densely setiferous.

The eye is comparatively larger than in *M. australiensis*, almost completely filling up the frontal part of the head, and the crystalline bodies seem also to be more numerous.

The antennulæ (fig. 3) are distinguished by their unusual length, being comparatively nearly twice as long as in the preceding species. They are very narrow, sublinear in form, and provided behind with scattered, delicate hairs. The sensory bristle of the anterior edge occurs much nearer to the base than to the tip, being placed at about the end of the first third part of the length of the antennula.

The antennæ do not exhibit any essential difference from those in the preceding species; the 1st pair of legs (fig. 4) too are constructed in the very same manner, the subapical seta being, as in that species, quite simple.

The tail (fig. 5) likewise looks rather similar. But, on a closer examination, the terminal claws are found to differ essentially in being each provided at the base with a well-marked, comb-like series of secondary teeth (see fig. 6).

A similar armature, as is well known, is found in *M. brachiata*, whereas in the other European species, *M. paradoxa*, the claws are quite smooth, as in *M. australiensis* and *M. propinqva*.

The ephippium (fig. 7), as in the preceding species, always contains 2 egg-ampullæ, which in this form, however, are placed more transversely, or in a manner similar to that figured by Prof. Weismann in the ephippium of *M. paradoxa*. Before the ephippium is detached from the shell, the 2 winter-eggs occupy (see fig. 2) a similar juxtaposed situation in the matrix to that observed in the preceding species.

The adult male (fig. 8) scarcely exceeds a length of 0,70 mm., and on the whole closely resembles the male of *M. australiensis*, though the antennulæ appear still more elongated, considerably exceeding half the length of the body. The 1st pair of legs are constructed in the very same manner as in the male of the said species, and the zoosperms in this form also are represented by simple, clear, nucleated cells.

As in the preceding species, the body in both sexes is highly transparent, especially in the male. In the female generally a faint bluish violet tinge, more rarely changing to reddish, may be observed. The winter-eggs are brick-red.

Observations.—This form was also raised in considerable numbers in some of my aquaria, and was watched during numerous succeeding generations. All the specimens exactly agreed with each other, as to the form of the head, the slender antennulæ, and the denticulated claws of the tail. Its habits are much as in the preceding species.

Occurrence.—The mud that yielded this species, was taken by Mr. Whitelegge from a pond at the corner of Bourke Street and Botany Road. A spirit sample from the same place contained numerous specimens of the same species, exactly agreeing with those raised here in Christiania.

Gen. **Moinodaphnia**, Herrick.

Syn. Paramoina, G. O. Sars.

9. Moinodaphnia Macleayii (King).

Moina Macleayii, King, l. c., p. 251, Pl. V.

A solitary, somewhat imperfect female specimen, apparently of this form, was found in a sample taken by Mr. Whitelegge from the Marubra Swamp. Mr. King collected this form in a pond near Elisabeth Ray.

Fam. Lyncodaphnidæ.

Gen. **Macrothrix**, Baird.

10. Macrothrix spinosa, King.

Macrothrix spinosa, King, l. c. p. 256, Pl. VI E.

Macrothrix spinosa, G. O. Sars. Additional Notes on Austr. Cladocera raised from dried mud, p. 25, Pl. 3.

Some specimens of this form, described and figured in detail by the author in the above-quoted paper, were found in a sample taken by Mr. Whitelegge from a pond near Sydney.

Distribution.—Queensland (G. O. Sars).

Gen. **Ilyocryptus**, G. O. Sars.

11. Ilyocryptus sordidus (Liëvin).

(Pl. 5, figs 1—3).

Acanthocercus sordidus, Liëvin, Die Branchiopoden der Danziger Gegend: Neueste Schriften der naturf. Gesellsch. in Danzig, p. 34, Pl. VIII, figs. 7—12.

In one of my aquaria there developed several specimens of an *Ilyocryptus*, which I am unable to distinguish from the well-known European species *I. sordidus*, Lièviu. In order to show the identity of both forms, I have given on the accompanying plate a figure of a full-grown female specimen, together with more highly magnified detail figures of one of the antennulæ and of the tail. The specimens, which exhibited a blood-red colour, did not exceed a length of 0,57 mm.

As in most other species of the genus, the shell is not completely cast off by the several exuviations of the animal, and in fully grown specimens (fig. 1), therefore each valve has the appearance of being composed of a more or less considerable number of superposed valves of different sizes, most of them still exhibiting their marginal setous armature. It is chiefly on this account that the animal is generally found so densely covered with mud as to be scarcely recognizable. Indeed, the mud adheres so firmly to the numerous rows of bristles, that it is a matter of great difficulty to cleanse the shell sufficiently for a minute examination. The specimens were only found on the bottom, more or less deeply buried in the loose muddy deposit, through which they moved very slowly by the aid of the antennæ and the powerful tail. I have never seen the animal make even the slightest attempt to lift itself from the bottom, and in this respect it differs rather markedly from the 2nd Australian species, *I. longiremis*, which is by no means devoid of swimming power.

Occurrence.—The specimens were raised from the same parcel of mud, which yielded the above-described *Moina tenuicornis*. As above stated, this mud was derived from a pond at the corner of Bourke Street and Botany

Road. In a sample taken by Mr. Whitelegge from another pond off Botany Road, near Waterworks Bridge, some few specimens of the same form were contained. Moreover, the author has raised this species from mud collected in China.

Fam. Lynceidæ.

Gen. **Chydorus**, Baird.

12. Chydorus Leonardi, King.

(Pl. 5, figs. 4, 5).

Chydorus Leonardi, King, l. c. p. 258, Pl. VII C.

Syn.: Chydorus minor, Lilljeb. M. S.

This form, first described by Mr. King, is undistinguishable from a small *Chydorus,* which is rather common in Norway, as also in Sweden, and for which Prof. Lilljeborg has proposed the name of *Chydorus minor.* As shown by the figures here given, it is very nearly allied to *C. sphæricus* (Müll.), but is of much smaller size, and without any trace of the reticulation of the shell characterising that species. The specimen here figured, which measured in length 0,25 mm., was picked up from a sample taken from the Waterloo Swamps, near Sydney.

Of the same form numerous specimens also developed in some of my aquaria, and continued to live and propagate during the whole season. They were rather active, moving about in the water in a somewhat revolving manner, at times affixing themselves to the walls of the aquarium or to the plants growing in it.

Occurrence.—Mr. King found this form in several places around Sydney: near Wavely Mills; the waterfall, St. Leonard's; South Creek; Denham Court. To these localities may now be added the followings: Waterloo Swamps; pond opposite Lachlan Street; off Botany Road, near Waterworks Bridge.

In all probability, the species is distributed all over Europe, Asia, Africa and America, being a true cosmopolite.

13. Chydorus globosus, Baird.

(Pl. 5, figs. 6—7).

Chydorus globosus, Baird, Brit. Entomostraca, p. 127, Pl. XVI, fig. 7.

Chydorus augustus, King, l. c. p. 258, Pl. VII B.

There cannot, I believe, be any doubt that this is the true *Chydorus augustus* of King. This form however, as shown by the figures given on the accompanying plate, is undistinguishable from the well-known European species *C. globosus* of Baird, and, as the name given by Baird is much the older of the two, it ought to be retained for the species. The solitary specimen here figured, which measured 0,65 mm. in length, was found in a sample from the Centennial Park. Mr. King collected the species from a pond on the Road to Botany Bay.

Gen. **Pleuroxus**, Baird.

14. Pleuroxus inermis, G. O. Sars, n. sp.

(Pl. 5, figs. 8, 9).

Specific Characters.—☿ Shell, seen laterally, of an irregularly rounded form, and narrowly truncated posteriorly, dorsal margin boldly curved, ventral somewhat protuberant in front, and nearly straight behind, infero-posteal corners rounded off, and without any trace of denticles. Head strongly procumbent, terminating in a long and sharply pointed rostrum. Surface of valves smooth, except in their anterior part, where they are sculptured with 10—12 very conspicuous, curved, transverse striæ, inferior edges densely ciliated. Ocellus much smaller than the eye. Tail nearly of uniform breadth, and obtusely truncated at the tip, posterior edge somewhat flexuous, post-anal angle very slight, ante-anal denticles extremely small, hair-like, terminal claws strong and curved, each with 2 secondary denticles at the base. Colour light corneous. Length of adult female 0,60 mm.

Remarks.—In a previous paper[1]) I have wrongly identified this species with *Chydorus augustus* of King, which, as above stated, is identical with *C. globosus*, Baird. The present form, which is a true *Pleuroxus*, is very closely allied to the European species *P. aduncus*, Jurine, and exhibits a very similar sculpturing of the valves, but differs in the more rounded form of the shell, and very markedly in the rounding off of the infero-posteal corners of the valves, where there is no trace of the denticles found here in all the other known species of the genus.

Description of the female.

The length of adult specimens measures 0,60 mm., and this form is accordingly of about the same size as the European species, *P. aduncus*.

The shell is moderately tumid, and, seen laterally (fig. 8), of a somewhat irregularly rounded form, the greatest breadth being but little inferior to the length, and occurring

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[1]) On a small collection of Fresh-water Entomostraca from Sydney (Chr. Vid. Selsk. Forh. 1889) p. 5.

somewhat in front of the middle. It is narrowly truncated posteriorly, and strongly vaulted above, the dorsal margin forming a bold and rather even curve until the tip of the rostrum. The inferior edges of the valves are somewhat protuberant in front of the middle, and join the anterior edges by an abrupt curve; behind, they appear nearly straight, or very slightly convex in the middle, and ascend obliquely to the infero-posteal corners, which are evenly rounded off. The head is very procumbent, and, as in the other species of the genus, to a certain degree mobile, admitting of being bent in against the anterior part of the valves. It terminates in a long and sharply-pointed rostrum, which curves somewhat posteriorly, and projects considerably beyond the free edges of the valves. The fornix appears as an elevated sigmoid ridge, which joins the valves at a very acute angle.

The surface of the shell appears, in its greater part, quite smooth, without any perceptible reticulation. In the most anterior part of the valves, however, a very conspicuous sculpturing is traced, consisting of from 10 to 12 curved, transverse striæ, which run parallel to the anterior edges, and are very sharply marked. The inferior edges of the valves are throughout fringed with delicate bristles, which, especially in their posterior part, are rather conspicuous and finely ciliated. The infero-posteal corners are quite smooth, without the slightest trace of the strong denticles occurring here in other species.

The eye is of moderate size, and occupies its usual place.

The ocellus is scarcely half as large, and occurs much nearer to the eye than to the tip of the rostrum.

The antennulæ are short and thick, extending scarcely beyond the middle of the rostrum.

The antennæ are comparatively short, and of the usual structure.

The tail (fig. 9) is of moderate size, and almost of uniform breadth throughout, being obtusely truncated at the tip, with the posterior corner rounded off. The post-anal angle is but little prominent, and is obtuse. The posterior edge below it appears very slightly flexuous, being somewhat convex in the middle. The ante-anal denticles are very small, almost hair-like, and occupy the outer half of the edge, being continued around the distal corner. The terminal claws are rather strong and curved, having each 2 distinct secondary denticles at the base, not found in the European species *P. aduncus*.

As in most other Lynceidæ, the matrix never contains more than 2 ova or embryos, which are generally juxtaposed.

The body in living specimens is semi-pellucid, thus showing through the integuments several of the inner organs, especially the dark-coloured and twisted intestinal tube. It generally exhibits a yellowish or light corneous hue.

Observations.—Of this species some specimens were found in one of my aquaria, all of them females. They did not, however, multiply to any greater extent, and in the latter part of the summer, this form wholly disappeared. The animal is rather agile, moving quickly through the water in much the same manner as the species of *Chydorus*. Very often it was also seen clinging to the wall of the aquarium or to the plants growing in it.

Occurrence.—The mud, from which I raised this species, was taken by Mr. Whitelegge from a pond opposite Lachlan Street, Bourke Street; and in a sample from the same locality, a considerable number of specimens was contained. It also occurred in the sample first received from Prof. Ramsay, and taken from the Waterloo Swamps.

Gen. **Alona**, Baird.

15. Alona Whiteleggii, G. O. Sars, n. sp.

(Pl. 6, figs. 1, 2).

Specific Characters.—♀ Shell, seen laterally, oval quadrangular, but very slightly widening behind, dorsal margin evenly arcuate, ventral nearly straight, hind extremity somewhat obliquely truncated, with the upper corner obsolete, lower rounded off. Head somewhat procumbent, terminating in an acute rostrum. Surface of shell striated longitudinally, inferior edges densely ciliated. Ocellus almost as large as the eye. Tail rather large, lamellar, though scarcely widening distally, being obtusely truncated at the tip, post-anal angle almost obsolete, posterior edge below it very slightly convex, of ante-anal denticles about 15 pairs, each accompanied by a squamiform lateral denticle, terminal claws each with a rather strong secondary denticle at the base. Length of adult female 0,63 mm.

Remarks.—This form is somewhat intermediate in character between the European species, *A. qvadrangularis* and *oblonga,* without being referable to either of them. In size and sculpture it more resembles the first-named species, but the form of the shell and that of the tail is rather different, and agrees more with that found in *A. oblonga.* I have much pleasure in dedicating this beautiful species to Mr. Whitelegge, to whom I am indebted for the greater part of the material here treated off.

Description of the female.

The length of the specimen examined, which is a fully grown ovigerous female, measures 0,63 mm., and is accordingly somewhat inferior to that of both the above-named European species.

Seen laterally (fig. 1), the shell exhibits an oval quadrangular form, with the greatest breadth about in the middle. The hind extremity is obliquely truncated, and not nearly so broad as in *A. qvadrangularis*, and with the inferior corner the more prominent. The dorsal margin forms a perfectly even curve until the tip of the rostrum, and joins the hind edge without any distinct intervening angle. The inferior edges of the valves are nearly straight and horizontal, though slightly ascending in front to the anterior corners. Behind, they join the posterior edges by a rather sharp but perfectly even curve. The head is somewhat procumbent, not nearly so erect as in the 2 European species, and terminates in an acute, somewhat hooded rostrum.

The surface of the shell is sculptured with well-marked, and rather closely set, longitudinal striæ, about 20 on each side. These striæ are more conspicuous in the posterior part of the shell, disappearing gradually in front. The inferior edges of the valves are throughout fringed with delicate bristles.

The eye is well developed, exhibiting some few very conspicuous crystalline bodies.

The ocellus is comparatively large, almost attaining the size of the eye, and occurs somewhat nearer to it than to the tip of the rostrum

The antennulæ are rather narrow and sub-fusiform, and do not quite extend to the tip of the rostrum. They are provided at the tip with a bundle of somewhat unequal olfactory papillæ, and have, moreover, each a delicate sensory bristle projecting from the anterior edge about in the middle.

The antennæ are well developed, and exhibit the normal structure.

The lamellar expansion of the labrum is of moderate size, and exhibits the usual securiform shape, its edge being quite smooth.

The tail (fig. 2) is rather large, lamellar, and almost of equal breadth throughout, or but very slightly expanded distally, being obtusely truncated at the end, with the posterior corner rounded off. The post-anal angle is rather indistinct, nearly obsolete, and the posterior edge below it, very slightly convex, exhibiting a double row of well-defined denticles, about 15 in each row. Somewhat within the edge, moreover, occurs on each side a lateral row of very delicate, somewhat squamiform denticles, corresponding in number with the marginal ones. The terminal claws are rather strong, and each armed at the base with a comparatively large secondary denticle.

Occurrence.—The above-described specimen, the only one I have seen, was found in a sample taken by Mr. Whitelegge from the Centennial Park, near Sydney.

16. Alona pulchella, King.

(Pl. 6, figs. 3, 4).

Alona pulchella, King, l. c. p. 260, Pl. VIII B.

Specific Characters.—Shell, seen laterally, oblong quadrangular, not widening at all behind, posterior extremity obtusely truncated, with the lower corner rounded off, dorsal margin evenly arcuate, ventral straight. Head sub-erect, terminating in an acute rostrum. Surface of shell faintly striated longitudinally. Ocellus much smaller than the eye. Tail comparatively short and of uniform breadth, transversely truncated at the tip, with the posterior corner well defined, postanal angle distinct, though obtuse, posterior edge below it perfectly straight and armed with a double row of very delicate denticles, in front of which there is on each side a lateral series of still more delicate, squamiform spinules, terminal claws rather elongated, each with a distinct secondary denticle at the base. Length of adult female 0,58 mm.

Remarks.—This is, as I believe, the form originally recorded by Mr. King under the above name. It is closely allied to another Australian species described by the present author from the northern part of the country as *A. lævissima*. But in the latter form, as indicated by the specific name, the shell is perfectly smooth, whereas in the present species it exhibits the usual longitudinal striation.

Description of the female.

The length of adult, ovigerous specimens does not exceed 0,58 mm., and is accordingly rather inferior to that of the preceding species.

The form of the shell, when seen laterally (fig. 3), is oblong quadrangular, being scarcely wider behind than in front. The posterior extremity appears obtusely truncated, with both the upper and lower corners rounded off, the latter being the more prominent. The dorsal margin is quite regularly arcuate until the tip of the rostrum, and has its greatest curvature about in the middle, whereas the ventral one appears almost straight and horizontal. The head is less procumbent than in the preceding species, and terminates in an acute rostrum, somewhat shorter than in that species.

The surface of the shell is sculptured with distinct, though not very sharply marked, longitudinal striæ, which are less closely set than in the preceding species, their number being from 14 to 15 on each side. The inferior edges of the valves are, as usual, densely ciliated.

The eye is well developed, with distinct, though small crystalline bodies.

The ocellus is much smaller than the eye, and placed a little nearer to it than to the tip of the rostrum.

The antennulæ exhibit the usual narrow subfusiform shape, and do not extend to the tip of the rostrum.

The antennæ are less powerful than in the preceding species.

The lamellar expansion of the labrum is rather large, and has the edge perfectly smooth.

The tail (fig. 4) closely resembles that in *A. lævissima*, being comparatively short, and of uniform breadth. It is transversely truncated at the tip, with the posterior corner well defined and somewhat produced. The post-anal angle is distinctly marked, though not very prominent, and the posterior edge below it appears perfectly straight, carrying a double row of very small, hair-like denticles, 10—12 in each row. As in the preceding species, there is on each side an additional lateral row of extremely delicate, somewhat squamiform spinules. The terminal claws are considerably elongated, and each exhibit at the base a well-marked secondary denticle.

Occurrence.—Some few specimens of this form, all of them females, were found in the sample at first received from Prof. Ramsay, and taken from the Waterloo Swamps.

Mr. King collected the species at Varroville, near Denham Court, and also at St. Leonards, near Sydney. In the samples taken by Mr. Whitelegge, this species did not occur.

17. Alona abreviata, G. O. Sars, n. sp.
(Pl. 6, figs. 5, 6).

Specific Characters.—♀. Shell comparatively short and stout, and, seen laterally, of irregular quadrangular form, broadest in front of the middle, posterior extremity transversely truncated, dorsal margin abruptly curved in front, ventral slightly convex anteriorly. Head somewhat flattened above, semi-erect, terminating in a rather prominent, acute rostrum. Surface of shell sculptured in its posterior part with obliquely longitudinal lines, which are somewhat flexuous, so as to form an indistinct reticulation, anterior part of valves transversely striated, inferior edges ciliated. Ocellus smaller than the eye. Lamellar expansion of the labrum with a distinct notch anteriorly. Tail short and stout, obtusely truncated at the end, with the posterior corner evenly rounded, and armed on each side with about 10 well-defined denticles, post-anal angle rather prominent, and occurring at about the middle, terminal claws of moderate size, and each armed with a small secondary denticle. Colour pale corneous. Length of adult female 0,37 mm.

Remarks.—This form, at the first sight, looks very like the New Zealand species, *A. macrocopa*, described by the present author in another paper, but differs, on a closer comparison, in the somewhat different sculpture of the shell, as also in the minor development of the antennæ. Both these species form, as it were, a transition to the genus *Alonella*, though being distinguished from the species of that genus by the immobility of the head, as in the other species of *Alona*.

Description of the female.

Fully adult, ovigerous specimens do not exceed a length of 0,37 mm., and this form is accordingly of very small size.

The shell is unusually short and stout, exhibiting, in a lateral view of the animal (fig. 5), a somewhat irregular quadrangular form, with the greatest breadth somewhat in front of the middle. The posterior extremity appears transversely truncated, with the upper corner well marked, the lower rounded off. The dorsal margin is boldly arched, forming an abrupt curve at the junction with the head, whereas the ventral one appears straigther, though exhibiting a slight convexity in front of the middle. The head is semi-erect, and has the dorsal face somewhat flattened, its upper edge being almost straight and declining towards the rostrum; the latter is rather prominent and, when seen laterally, acuminate.

The surface of the shell is very distinctly sculptured, exhibiting in its posterior part a number of obliquely longitudinal lines, which appear somewhat flexuous, thus forming an indistinct reticulation. These lines, in the anterior part of the valves, are crossed by a set of curved, transverse striæ, running parallel to the anterior edges, and rather sharply marked. The inferior edges of the valves are, as usual, densely ciliated.

The eye is of moderate size, and in its usual situation.

The ocellus occurs somewhat nearer to it than to the tip of the rostrum, and is of very inferior size.

The antennulæ exhibit the usual structure, and do not extend to the tip of the rostrum.

The antennæ are of normal appearance, not being of any unusual size.

The lamellar expansion of the labrum is rather large, and exhibits in front a distinct notch not found in the other known species.

The tail (fig. 6) is short and thick, on the whole resembling in shape that in *A. macrocopa*, though having the tip less obliquely blunted, and the rounded posterior corner more prominent; around the latter, a double series of from 8 to 10 well-defined denticles occur. The post-anal angle, as in *A. macrocopa*, is rather prominent, and placed nearly in the middle of the posterior edge.

The colour in living specimens is yellowish, or pale corneous.

Observations.—This form developed rather plentifully in one of my aquaria, and during one period of the season, it occurred in such numbers, that I was almost sure to get some specimens, on taking up, by the aid of a dipping tube, a very small portion of the loose bottom deposit, and examining it in a watch-glass. In the latter part of the summer, however, it almost wholly disappeared, and no male specimens were for this reason secured. It moves through the water in the very same manner as most other species of the genus, the movement being quite even and somewhat tremulous, not, as is the case with the New Zealand species, by abrupt jerks.

Occurrence.—The mud from which this form was raised, was taken by Mr. Whitelegge from a pond at the corner of Bourke Street and Botany Bay. The species also occurred in a sample from the same locality, but in a very limited number.

Gen. **Alonella**, G. O. Sars.

18. Alonella diaphana (King).

Alona diaphana, King, l, c. p. 360, Pl. VIII C.

Alonella diaphana, G. O. Sars, Add. Notes Austr. Cladocera, p. 47, Pl. 5, figs. 5—7.

This form, described and figured in detail by the present author in the above-mentioned paper, developed in the same aquarium as *Alona abbreviata*, but did not occur in any considerable number. It was, moreover, found in a sample taken by Mr. Whitelegge from the Centennial Park, though rather scarce.

19. Alonella clathratula, G. O. Sars, n. sp.
(Pl. 6, figs. 7, 8).

Specific Characters.—♀ Shell, seen laterally, oblong oval, greatest breadth in front of the middle, posterior extremity narrowly truncated, with the lower corner well defined, simple; dorsal margin evenly arcuate, ventral somewhat flexuous and convex in front. Head procumbent, produced to a sharply-pointed rostrum. Surface of shell very distinctly sculptured, exhibiting posteriorly a rather regular reticulation, anterior part of valves striated transversally. Ocellus much smaller than the eye. Tail rather narrow, not widening distally, post-anal angle well-marked, tip narrowly truncated, ante-anal denticles very small, hair-like, terminal claws of moderate size, each with a well-marked secondary denticle at the base. Length of adult female 0,36 mm.

Remarks.—This form is somewhat nearly allied to the European species, *A. excisa*, Fisher, but differs in the more elongated form of the shell, and in the infero-posteal corners being simple, not excised.

Description of the female.

The length of fully adult, ovigerous specimens does not exceed 0,36 mm., and this form is accordingly of rather small size.

The form of the shell, when seen laterally (fig. 7), is oblong oval, with the greatest breadth about in the middle, and the posterior extremity narrowly truncated. The dorsal margin is quite evenly arcuate, and forms with the posterior one a distinct, though somewhat obtuse angle.

The inferior edges of the valves are somewhat flexuous, being rather convex in front, but posteriorly assuming a straighter course. They are defined from the posterior edges by a distinctly projecting corner, which sometimes terminates in a sharp point. No notch, however, like that generally occurring in *A. excisa*, is ever found above this corner.

The head, as in most other species of the genus, is rather procumbent, terminating in a long, acuminate, somewhat posteriorly-curving rostrum.

The surface of the shell is very conspicuously sculptured, exhibiting in its posterior part a rather regular reticulation, the meshes being disposed in oblique rows, whereas anteriorly, each valve exhibits a number of sharply-marked, curved, transverse striæ. The inferior edges of the valves are densely fringed with delicate bristles.

The eye occupies its normal place, and is of moderate size.

The ocellus occurs much nearer to the eye than to the tip of the rostrum, and is of very inferior size.

The antennulæ are comparatively short and thick, scarcely extending beyond the middle of the rostrum.

The antennæ are rather small, and of the usual structure.

The tail (fig. 8) is comparatively narrow, and somewhat resembles in form that in *A. excisa,* not being at all expanded distally, and having the tip narrowly truncated. The post-anal angle is well defined, though not very prominent, and the ante-anal denticles are very small, almost hair-like, and present to the number of about 10 pairs. The terminal claws are not very strong, and have each a minute secondary denticle at the base.

Occurrence.—Some specimens of this small Lynceid were picked up from a sample taken by Mr. Whitelegge from the Marubra Swamp, near Sydney. The specimens were of a very dark grey hue.

Gen. **Camptocercus**, Baird.

20. Camptocercus australis, G. O. Sars, n. sp.

(Pl. 6, figs. 9, 10).

Specific Characters.—♀ Shell highly compressed and, seen laterally, of oblong form, broadest in front, posterior extremity narrowly rounded, dorsal margin evenly convex, ventral bulging anteriorly, straight behind. Head rather large, crested, terminating in a deflexed, blunt rostrum. Surface of shell longitudinally striated; inferior edges ciliated in the middle and not exhibiting any trace of denticles at the infero-posteal corners. Eye small; ocellus still smaller, both occurring at a rather considerable distance from the anterior edge of the head. Tail very slender and elongated, conically tapering distally, post-anal angle well-marked, ante-anal denticles about 20 pairs, terminal claws slender, each with 2 distant secondary denticles. Length of adult female 0,74 mm.

Remarks.—This form looks very like the well-known European species, *C. macrurus*, Müll., but is at once distinguished by the total abscence of the denticles found at the infero-posteal corners of the shell in that, as also in the other known species of the genus.

Description of the female.

The body, as in the other species, is highly compressed, and provided with a distinct crest, extending along the dorsal face of both the shell and the head. Seen laterally (fig. 9), the shell exhibits an oblong form, being broadest in front, and narrowed towards the posterior extremity, which appears obtusely rounded, without any angle below, and with the upper corner almost obsolete. The dorsal margin forms a rather even curve until the tip of the rostrum, whereas the ventral one appears somewhat flexuous, being rather protuberant in front, and assuming behind a more straight course. The head is rather large and somewhat procumbent, terminating in a blunt, deflexed rostrum. The fornical edge is but very slightly curved, and joins the shell on each side at a very acute angle.

The surface of the shell is sculptured with well-marked longitudinal striæ, about 18 on each side, and exhibits besides, in the most anterior part of the valves, a number of closely set, curved transverse lines. The inferior edges of the valves are fringed with delicate bristles, which successively diminish in length behind, and disappear altogether at some distance from the posterior extremity. Not even the slightest trace of any denticles is found behind the bristles at the infero-posteal corners of the shell, which appear perfectly smooth, and evenly rounded off.

The eye is rather small, and located at a considerable distance from the anterior edge of the head. This is also the case with the ocellus, which is much smaller than the eye, and occurs somewhat nearer to it than to the tip of the rostrum.

The antennulæ are rather slender and elongated, though not extending beyond the tip of the rostrum, except by their apical papillæ, which latter are rather fully developed, and of somewhat unequal length.

The antennæ are comparatively short, and of the usual structure.

The lamellar expansion of the labrum is not very large, but of the usual securiform shape, with the edge perfectly smooth.

The tail (fig. 10) exhibits the structure characteristic of the genus, being very slender and exceedingly mobile. It is of a narrow conical form, tapering gradually towards the end, which does not exhibit any notch or projecting corner behind the base of the terminal claws. The post-anal angle is well defined, and not far removed from the base of the tail. The posterior edge beyond the anal orifice is armed with a double row of about 20 well-defined denticles, the outermost of which is placed at some distance from the tip. The terminal claws are rather strong, and nearly straight, each having a well-defined secondary denticle at the base, and another somewhat smaller one about in the middle of the posterior edge.

Occurrence.—A solitary, but well preserved female specimen of this form was found in a sample taken by Mr. Whitelegge from the Centennial Park, near Sydney.

Trykt den 15de Juli 1896.

Ostracoda.

Fam. Cyprididæ.

Gen. Cypria, Zencker.

21. Cypria pusilla, G. O. Sars, n. sp.

(Pl. 7, fig. 1, a—b).

Specific Characters.—♀ Shell much compressed and, seen laterally, almost semicircular in form, anterior extremity, however, lower than the posterior, dorsal margin boldly arched, ventral nearly straight; seen dorsally narrow oblong, both extremities somewhat blunted. Valves rather unequal, the right one being much the larger, and considerably overlapping the left in the middle of the dorsal face, as also anteriorly. Surface of shell smooth, but dotted all over with brownish pigment; both extremities clothed with delicate hairs. Length of adult female 0,58 mm.

Remarks.—This form is nearly allied to the European species, *C. ophthalmica* (Jurine), but of much smaller size, and, moreover, distinguished by the very conspicuous inequality of the valves.

Description of the female.

The length of the shell in fully grown specimens does not exceed 0,58 mm., and this form is accordingly of very small size as compared with the European species.

The shell is highly compressed and, viewed from the side (fig. 1 a), of a somewhat semicircular outline, with the greatest height about in the middle. The anterior extremity is somewhat oblique, and much lower than the posterior, which is broadly rounded. The dorsal margin forms a bold, and rather even curve, joining the anterior and posterior edges, without any intervening angle. The ventral margin appears almost straight, though there is a slight approach to a median sinus. Seen from above (fig. 1 b), the shell appears narrowly oblong, with the lateral contours nearly parallel, and both extremities somewhat blunted, though the anterior is somewhat narrower than the posterior.

The valves are very unequal, the right one being much the larger, and projecting considerably beyond the left along the middle of the dorsal face. Anteriorly it overlaps the left valve by a thin hyaline border, and a similar, though much narrower border is also seen at the infero-posteal corner.

The surface of the shell is perfectly smooth, without any distinct sculpturing. It is, however, dotted all over with a reddish brown pigment, similar to that found in *C. ophthalmica*. At each extremity the shell is clothed with very delicate hairs, somewhat more densely crowded together anteriorly. The eye may be pretty well traced through the shell, and the muscular pits in the centre of each valve are also rather conspicuous.

Occurrence.—Of this small species, solitary specimens were picked up from a sample taken by Mr. Whitelegge from the Waterloo Swamps.

Gen. **Cypris**, Müll.

22. Cypris bennelong, King.

Cypris bennelong, King, Proc. Roy. Soc. Van Diemen's Land, 1855, p. 63, Pl. X. A.

Cypris bennelong, G O. Sars, Fresh-water Entomostraca of New Zealand, p. 24, Pl. IV, figs. 1, a—d.

Syn. Chlamydotheca australis, Brady.

Of this characteristic form, described and figured by the present author in the above-quoted paper, numerous specimens were found in 2 different samples taken by Mr. Whitelegge from waterholes at Bourke Street. It is rather singular, that not even a single specimen of this species developed in my aquaria, though empty shells were not uncommon in the mud, with which these were prepared.

Distribution.—New Zealand (G. O. Sars).

23. Cypris sydneia, King.

Cypris sydneia, King, l. c. p. 65, Pl. X. M.

Cypris sydneia, G. O. Sars, Fresh-w. Ent., N. Z., p. 27, Pl. IV, figs. 2, a–c.

Syn. Cypris ciliata, Thomson.

This form, which exhibits so close a relationship to the European species, *C. incongruens,* developed rather plentifully in some of my aquaria, and grew to a much larger size than the specimens raised by the present author from New Zealand mud. It was also found in great numbers in some samples taken by Mr. Whitelegge from waterholes at Bourke Street, and in addition to these, a single, young specimen occurred in the sample first received from Prof. Ramsay, and taken from the Waterloo Swamps.

Distribution.—New Zealand.

24. Cypris leana, G. O. Sars, n. sp.

(Pl. 7, figs. 2, a—d).

Specific Characters.—Shell large, seen laterally, oval reniform, greatest height in the middle, anterior extremity evenly rounded, posterior subtruncate and scarcely broader than the anterior, dorsal margin almost angularly bent in the middle, ventral but very slightly sinuate; seen dorsally oblong cuneiform, gradually tapering in front, anterior extremity acuminate, posterior obtuse. Valves nearly equal, left one having the edge minutely tuberculated in front and behind; inner duplicatures not very broad. Surface of shell remarkably smooth and polished, being clothed at both extremities with minute hairs. Caudal rami rather slender and slightly flexuose, narrowed distally, outer claw about half the length of the ramus. Length of shell 2,70 mm.

Remarks.—The present species is allied to *C. sydneia*, but is evidently distinct from it, being nearly twice as large and having the shell higher in proportion to its length. It is named in honour of its discoverer, Mr. Lea.

Description of the female.

The length of the shell measures 2,70 mm., and this form accordingly grows to a very large size.

Seen laterally (fig. 2 a) the shell exhibits a somewhat irregular, oval reniform shape, with the greatest height, which about equals $^3/_5$ of the length, occurring in the middle. The anterior extremity is quite evenly rounded, whereas the posterior one appears somewhat obtusely truncated, and is scarcely broader. The dorsal margin is boldly arched, being almost angularly bent in the middle, and slopes at about the same angle both anteriorly and posteriorly. The ventral margin appears nearly straight, though a slight sinus may be traced in the middle.

Seen from above (fig. 2 b), the shell exhibits an oblong cuneiform shape, with the greatest width, which about equals half the length, occurring far behind the middle. Anteriorly it is gradually narrowed to a somewhat twisted acute point, whereas the posterior extremity is more obtusely rounded.

The valves, at first sight, appear nearly equal. On a closer examination, however, the left one is found to be somewhat larger than the right, overlapping it anteriorly by a narrow, hyaline border; and below the posterior extremity a similar projecting rim may also be traced. As in *C. sydneia,* the right valve exhibits at the anterior edge and at the posterior part of the ventral one, a series of small knobs or tubercles, giving the edge a minutely crenulated appearance. The inner duplicatures are rather narrow, though the anterior one is somewhat broader than the posterior.

The surface of the shell is remarkably smooth and polished, without any perceptible sculpturing, except the usual small dots; and it is only at each extremity that it is clothed with very small hairs. The muscular pits in the centre of each valve are fairly conspicuous, and resemble those in *C. sydneia.*

The colour of the shell could not be ascertained, as the specimens were discoloured by long immersion in spirit.

The caudal rami (fig. 2 c) are of moderate size and rather slender, tapering somewhat distally, and exhibiting a slight flexure. They are armed in the usual manner, each having at the end 2 unequal claws and 2 bristles. The claws are rather slender, the outer one being half the length of the ramus.

Occurrence.—A rather considerable number of this pretty species were contained in a sample taken by Mr. Lea from a pond «Near Hay».

25. Cypris lateraria, King.

(Pl. 7, figs. 3, a—c).

Cypris lateraria, King, l. c., p. 65, Pl. X G.

Specific Characters.—Shell ventricose, seen laterally, clavate in form, much higher in front than behind, anterior extremity broadly rounded, posterior subtruncate, dorsal margin subangular above the eye, and gradually sloping behind, ventral deeply sinuated: — seen dorsally, regularly ovate, with the greatest width fully equalling the height, and occurring behind the middle, anterior extremity more pointed than the posterior. Valves very unequal, the left one being much the larger, and overlapping the right both anteriorly and posteriorly. Surface of shell of a dull appearance, being distinctly granular all over, and also armed with scattered tubercles, more conspicuous towards both extremities, which are densely hairy. Caudal rami moderately strong, nearly straight, outer claw not attaining half the length of the ramus. Colour of shell uniformly yellowish green. Length 1,05 mm.

Remarks.—This is a very distinct species, and undoubtedly that recorded by Mr. King under the above name. In outward appearance it somewhat resembles the species of the genus *Ilyocypris,* and, indeed, I at first believed it to belong to that genus. A closer examination of the several appendages has, however, shown it to be a true *Cypris.*

Description of the female.

The length of the shell, in fully grown specimens, but little exceeds 1 mm., and this form is accordingly of rather small size.

Seen laterally (fig. 3 a), the shell exhibits a pronounced clavate form, being much higher in front than behind, with the greatest height equalling about half the length. The anterior extremity is broadly rounded, whereas the posterior one appears somewhat obliquely truncated, with the lower corner more prominent than the upper. The dorsal margin has its greatest curvature just above the eye, where it exhibits an almost angular bend, and from thence slopes evenly, and at a nearly straight course, to the hind extremity. The ventral margin is deeply sinuated somewhat behind the middle, and joins the posterior edge by an abrupt curve.

Seen from above (fig. 3 b), the shell appears very tumid, the greatest breadth, which occurs considerably behind the middle, fully equalling the height. It exhibits a rather regular ovate form, with the side-contours evenly curved, and the anterior extremity somewhat more pointed than the posterior.

The valves are very unequal, the left one being much larger than the right, and overlapping it considerably along the whole anterior extremity, as also posteriorly. The inner duplicatures are not particularly broad.

The surface of the shell is of a dull appearance, and often covered with muddy particles. It appears closely granular all over, exhibiting, as it were, a squamous sculpture. Moreover, a number of well-defined obtuse tubercles may be traced on each valve, being more conspicuous towards each extremity. Both anteriorly and posteriorly the shell is densely hairy.

The colour of the shell, in living specimens, is a rather uniform yellowish green.

The several appendages agree on the whole in their structure rather closely with those in the typical species of

Cypris, both pairs of antennæ being provided with very long natatory setæ, and the masticatory lobes of the 1st pair of maxillæ exhibiting the usual narrow, digitiform shape.

The caudal rami (fig. 3 c) are moderately strong, nearly straight, and but slightly narrowed distally. Their armature is the usual one, the outer claw being the longer, though not attaining half the length of the ramus.

Observations.—Some few specimens of this form developed in one of my aquaria, and were watched for some time. They did not, however, multiply to any great extent, and after the lapse of some months, no specimens were to be found in the aquarium. The animal is rather active, moving about through the water with great speed, at times affixing itself to the walls of the aquarium.

Occurrence.—The mud from which this species developed, was taken by Mr. Whitelegge from ponds and ditches at Bourke Street. Several well-preserved specimens also occurred in a sample taken by that gentleman from the same locality. Mr. King collected the species from a pond in a brickfield, near Sydney.

Gen. **Candonocypris**, G. O. Sars.

22. Candonocypris candonoides, King.

Cypris candonoides, King, l. c., p. 66, Pl. X F.

Herpetocypris stanleyana, G. O. Sars, On some Ostracoda and Copepoda raised from dried Australian mud, p. 35, Pl. II, figs. 1—2, Pl. V, figs. 5—7.

This form, whose identity with *Cypris candonoides* of King, I have stated in my paper on the New Zealand Entomostraca, developed rather abundantly in several of my aquaria, and was also found in great numbers in some of the samples sent by Mr. Whitelegge, and taken from ponds and ditches at Bourke Street.

Distribution. — Queensland, New Zealand, Knysna (G. O. Sars).

Gen. **Ilyodromus**, G. O. Sars.

27. Ilyodromus varrovillius, King.

Cypris varrovillius, King, l. c., p. 66, Pl. X D.

Ilyodromus varrovillius, G. O. Sars, Fresh-water Entomostraca of New Zealand, p. 41, Pl. VI, figs. 1, a—c.

In some of my aquaria this beautiful form developed rather plentifully, and continued to live and multiply during the whole season. It also occurred, though rather rarely, in the samples sent by Mr. Whitelegge, the locality being the same as that from which the preceding form was derived.

Distribution.—New Zealand (G. O. Sars).

28. Ilyodromus viridulus, Brady.

Cypris viridula, Brady, Proc. Zool. Soc. London, 1886, p. 88, Pl. VIII, figs. 1, 2.

Herpetocypris viridula, G. O. Sars, On some Fresh-water Ostracoda and Copepoda raised from Australian mud, p. 41, Pl. II, figs. 3, 4; Pl. V, figs. 8—11.

As observed in my paper on the New Zealand Entomostraca, this form ought to be referred to the genus *Ilyodromus*, as characterised by the author in that paper. It developed in the same aquarium as the preceding species, and was likewise found occasionally in the samples sent by Mr. Whitelegge.

Distribution.—Queensland (G. O. Sars).

29. Ilyodromus substriatus, G. O. Sars.

Ilyodromus substriatus, G. O. Sars, Fresh-water Entom. N. Zeal., p. 45, Pl. VI, figs. 3, a—c.

Some few specimens of this form were found in the samples sent from Mr. Whitelegge. It did not, however, develop in my aquaria.

Distribution.—New Zealand (G. O. Sars).

30. Ilyodromus ellipticus, G. O. Sars, n. sp.
(Pl. 7, figs. 4, a—c).

Specific Characters.—Shell much compressed, seen laterally, regularly oblong or elliptical in form, both extremities nearly equal and evenly rounded, dorsal margin but very slightly convex, ventral almost straight: — seen from above, narrow oblong, anterior extremity somewhat narrower than the posterior. Valves nearly equal and having the inner duplicatures very broad. Surface of shell very faintly striated longitudinally, and clothed at each extremity with scattered hairs, those of the posterior one being particularly long. Colour of shell transparent yellowish, each extremity, but especially the anterior one, being tinged with deep green. Caudal rami rather strong, and of the structure characteristic of the genus. Length 1,18 mm.

Remarks.—The present new species is somewhat allied to *I. substriatus,* exhibiting a similar faint longitudinal striation, but it may be at once distinguished by the rather different shape of the shell, which is more regularly oblong or elliptical than in any of the other known species.

Description of the female.

The length of the shell in fully grown specimens does not exceed 1,18 mm., and this form is accordingly somewhat inferior in size to *I. substriatus.*

Seen laterally (fig. 4 a), the shell exhibits a very regular oblong, or rather elliptical form, with the greatest height attaining not nearly half the length. Both extremities appear evenly rounded and nearly equal. The dorsal margin is but very slightly convex, without forming any trace of angle at the junction with the anterior and posterior edges. The ventral margin appears almost perfectly straight, the usual median sinus being quite obsolete.

Seen from above (fig. 4 b), the shell appears very much compressed, the greatest width scarcely exceeding $^1/_3$ of the length. Its form is very narrow oblong, with the side-contours but slightly convex, and the anterior extremity somewhat more pointed than the posterior.

The valves, at first sight, appear nearly equal. On a closer examination, however, the left valve, as in the other species, is found to be in reality a little larger than the right, overlapping it anteriorly by a very narrow hyaline rim. The inner duplicatures, especially the anterior ones, are very broad and shelf-like, and their defining edge may be pretty well traced through the shell.

The surface of the shell is indistinctly striated longitudinally, the striæ being very delicate, and in some cases only with great difficulty traceable. At both extremities it is clothed with delicate hairs, which on the posterior extremity are particularly long and far apart.

The colour of the shell in living specimens is transparent yellowish, allowing the cæcal appendages of the intestine and the opaque whitish ovarial tubes to be seen through rather distinctly. At each extremity it is tinged with deep green, this colour being especially very conspicuous anteriorly, where it occupies a rather broad, semilunar area inside the edge.

The eye is very large and conspicuous, exhibiting in the living animal a brillant iridescent lustre.

The several appendages closely agree in their structure with those in the other species of the genus.

This is also the case with the caudal rami (fig. 4 c), which are very strong, of a light corneous hue, and of about uniform breadth throughout. They are, as usual, armed at the end with 3 strong claws, successively increasing in size distally, the outermost one being, however, scarcely half the length of the ramus; just in front of it, the usual small bristle occurs.

Observations.—This form developed in some of my aquaria, but only in one of them did it multiply to any great extent. In habits, it agrees with the other species, moving with great dexterity through the loose bottom deposit, but being wholly devoid of swimming power.

Occurrence.—The mud from which this species developed, was taken by Mr. Whitelegge from waterholes at Bourke Street, and from a sample taken in the same place some few specimens of this form were also picked up.

Gen. **Cypridopsis**, Brady.

31. Cypridopsis minna, King.

(Pl. 7, figs. 5, a—c).

Cypris minna, King, l. c., p. 64, Pl. X B.

Cypridopsis minna, Brady, Proc. R. S. London, 1866, p. 91, Pl. X, figs. 1—3.

Specific Characters.—Shell moderately tumid; seen laterally, exceedingly high, of a rounded trigonal form, with the dorsal margin boldly arched and abruptly bent in the middle, ventral slightly sinuated, both extremities rounded and nearly equal; — seen from above broadly ovate, greatest width not exceeding the height, anterior extremity obtusely pointed, posterior evenly rounded. Valves rather unequal, the right one overlapping the left considerably in the middle of the dorsal face, as also anteriorly. Surface of shell smooth, or very slightly granular, moderately hairy, with a narrow, transversely-striated, marginal area just within the anterior edge of each valves. Colour yellowish, variegated with dark green, partly anastomosing patches. Length of shell 0,92 mm.

Remarks.—This is undoubtedly the true *C. minna* of King, and the form described by Brady also belongs quite certainly to the very same species. On the other hand, the form described by the present author under this name from New Zealand is specifically distinct, as will be shown farther on. The present species may be easily recognized from any of the other known forms by the extraordinary height of the shell, which gives it, in a lateral view, nearly a trigonal shape.

Description of the female.

The length of the shell in fully adult specimens measures 0,92 mm., and accordingly somewhat exceeds that of the said New Zealand form

Seen from the side (fig. 5 a), the shell exhibits a somewhat unusual form, being exceedingly high and almost trigonal in outline, with the greatest height not very inferior to the length, and occurring in the middle. Both extremities appear somewhat obliquely rounded, and nearly equal. The dorsal margin is very boldly arched, exhibiting an almost angular bend in the middle, and from thence sloping rather steeply both anteriorly and posteriorly. The ventral margin is but very slightly sinuated in the middle.

Seen from above (fig. 5 b), the shell appears less tumid than in the New Zealand form, and exhibits a rather regular rounded ovate form, the greatest width not exceeding the height. The anterior extremity is obtusely pointed, whereas the posterior one appears quite evenly rounded.

The valves are rather unequal, the right one being the larger, and overlapping the left not only along the anterior extremity, but also in the middle of the dorsal face. Somewhat below the centre of each valve, the muscular pits are observed, and just within the anterior edge, as in some other species, there is a narrow, very dark-coloured, marginal area, which exhibits a number of very conspicuous, light, transverse striæ.

The surface of the shell is smooth, or very slightly granular, being clothed all over with delicate hairs, which at each extremity are more densely crowded together.

The ground-colour of the shell in living specimens is yellowish and semi-transparent; but along the edges of the valves, as also in their centre, several dark-green patches occur, which are partly confluent, so as to form irregularly ramified bands.

The several appendages do not seem to differ in any manner from those in other species of the genus; the caudal rami too (fig. 5 c), exhibit the characteristic, very narrow linear form, with the claws extremely slender and almost setiform.

Observations.—This form developed rather plentifully in some of my aquaria, and continued to live and propagate during the whole summer. In habits, it exactly agrees with the other species of the genus.

Occurrence.—The mud from which this species developed, was the same parcel, that yielded most of the other

Cyprididæ here treated off, having been taken by Mr. Whitelegge from waterholes at Bourke Street. A sample taken from the same place, also contained numerous well preserved specimens.

32. Cypridopsis turgida, G. O. Sars, n. sp.

Cypridopsis minna, G. O. Sars, Fresh-water Entom. of N. Zeal. p. 20, Pl. IV, figs. 3, a—d.

As above stated, this form is evidently specifically distinct from the preceding one, with which I have wrongly identified it at an earlier date. It must therefore have another name, and I propose to call it *C. turgida,* on account of its extremely tumid shell.

This species too, developed in great numbers in my aquaria, and could at once be distinguished from the preceding one by its more tumid shell, and more uniform colouring. It was also found in the sample sent by Mr. Whitelegge.

Distribution.—New Zealand, Knysna, China (G. O. Sars).

Gen. **Candonopsis,** Vavra.

33. Candonopsis tenuis, Brady.

(Pl. 7, figs. 6, a—d).

Candona tenuis, Brady, Proc. R. S. London, 1886, p. 92, Pl. X, figs. 9, 10.

Specific Characters.—Shell much compressed, and of slightly different shape in the 2 sexes, being, however, in both, when seen laterally, more or less oblong reniform, with the hind extremity rounded and broader than the anterior; ventral margin distinctly sinuated, the sinus in female being median, in male, occurring somewhat in front of the middle, dorsal margin in female almost straight, with an indication of angle both anteriorly and posteriorly, in male evenly arched throughout: — seen from above, narrow oblong, more pointed in front than behind. Valves equal, smooth, semi-pellucid, of whitish colour, hairy at both extremities. Caudal rami very narrow, almost straight, and terminating with 2 somewhat unequal claws, each having beyond the middle a distinct secondary denticle, dorsal bristle wanting. Length of female 0.90 mm., of male 1.00 mm.

Remarks.—This, I believe, is the form briefly described and figured by Prof. Brady as *Candona tenuis*. It certainly belongs to the genus *Candonopsis*, as recently characterised by Mr. Vávra in his Monograph of the Ostracoda of Bohemia, and is nearly allied to the typical form *C. Kingsleyi*, though differing somewhat in the form of the shell, and apparently also in the structure of the caudal rami.

Description.—The length of the shell in adult female specimens scarcely exceeds 0.90 mm.; that of male specimens is somewhat greater, measuring 1.00 mm.

The shell in both sexes is highly compressed and, seen laterally (fig. 6 a, 6 b), of an oblong reniform shape, the greatest height scarcely exceeding half the length, and occurring behind the middle. Both extremities are rounded, and the anterior one is considerably narrower than the posterior, which appears somewhat compressed in its inferior part. The dorsal margin in the female (fig. 6 a) is nearly straight in the middle, with an indication of an angle both in front and behind, whereas in the male (fig. 6 b) this margin appears quite evenly arcuate. The ventral margin is in both sexes distinctly sinuated, but the sinus occurs in the male (fig. 6 b) somewhat in front of the middle, whereas in the female

Trykt den 16de Juli 1896.

(fig. 6 a) it is almost median. On the whole, the posterior part of the shell in the male (fig. 6 b) appears broader and more expanded than in the female (fig. 6 a), and the anterior extremity more produced. Seen from above (fig. 6 c), the shell in both sexes appears very narrow oblong, with the anterior extremity somewhat more pointed than the posterior.

The valves are nearly equal, and rather thin, are semipellucid, and clothed at each extremity with delicate hairs. The inner duplicatures are rather broad, especially the anterior ones, and their defining edges may be fairly well traced through the shell.

The surface of the shell appears quite smooth and polished, though exhibiting, when examined under a strong magnifier, an extremely delicate reticulation.

The colour of the shell in living specimens is transparent whitish, permitting several of the inner organs to be fairly well traced through it.

The eye is very small, and, it would seem, devoid of the usual dark pigment, being on that account rather difficult to trace.

The structure of the several appendages seems exactly to agree with that described by Mr. Vávra in the typical species, *C. Kingsleyi*.

The caudal rami (fig. 6 d), as in that species, are rather narrow, sublinear, and lack all trace of the usual dorsal bristle. They are, however, in the present species straighter, and each of the terminal claws has beyond the middle a very conspicuous secondary denticle, not found in the typical species.

In the male (fig. 6 b—c) the very large «mucous glands», or more correctly the «zenckerian organs» are distinctly traced through the shell, both in its lateral and dorsal views, appearing as 2 large, juxtaposed bags extending through the posterior half of the shell, and exhibiting within from 5 to 6 verticils of bristle-like radiating processes. Also the spermatic tubes contained within the 2 lamellæ of the valves may be fairly well discerned.

Observations.—An adult male specimen of this form, the one here figured, was by a mere chance found in one of my aquaria, on taking up, by the aid of a dipping tube, a small quantity of the bottom deposit. It was at once subjected to a closer examination under the microscope, and its habits studied. Though subsequently very closely examining the bottom contents of this aquarium, I did not succeed in detecting any more specimens. In habits, this form agrees with the typical species, as also with the species of the genus *Ilyodromus*, as it moves rather quickly through the loose bottom deposit, but is wholly devoid of swimming power.

Occurrence.—The mud, from which this form developed, was taken by Mr. Whitelegge from waterholes at Bourke Street. Numerous specimens of the same form, both males and females, moreover, occurred in a sample taken by that gentleman from the Marubra Swamp. The specimens examined by Prof. Brady were derived from Condong, Tweed River, New South Wales.

Copepoda.

Trib. Calanoidea. Fam. Diaptomidæ.

Gen. Boeckella, Guerne & Richard.

34. Boeckella triarticulata (Thomson).

Boeckia triarticulata, Thomson, Proc. N. Z. Inst. Vol. XV, 95, Pl. VI, figs. 1—9.

Boeckella triarticulata, G. O. Sars, Fresh-water Entom. N. Zeal., p. 49, Pl. VII & VIII.

Of this species, described and figured in detail by the author in the above-quoted paper, some few specimens, exactly agreeing in every detail with the New Zealand form, were found in a sample taken by Mr. Whitelegge from some pond near Sydney.

Distribution.—New Zealand (Thomson).

35. Boeckella robusta, G. O. Sars, n. sp.

(Pl. 8, figs. 1—4).

Specific Characters.—Anterior division of body in female rather thick and swollen, oblong oval in form, broadest in front of the middle, and slightly narrowed posteriorly, 1st segment about the length of the 4 succeeding ones combined, front narrowly rounded; lateral expansions of last segment scarcely divergent, extending beyond the 1st caudal segment, outer lobe large, broadly lanceolate, inner lobe very small, acute triangular. Tail, including the caudal lamellæ, not nearly half the length of the anterior division, 1st segment moderately tumid and slightly asymetrical. Caudal lamellæ nearly as long as the last 2 segments combined. Anterior antennæ scarcely exceeding in length the anterior division of the body; right prehensile antenna in male about as in *B. triarticulata*. Last pair of legs in female, with the terminal joint of the outer ramus shorter than the preceding joint, and armed with 7 spines, the outer apical one being rather strong; those in male, of the structure characteristic of the genus, inner ramus of right leg conically tapered, with a small curved seta inside the base, left leg without any serrated lamella at the base of the inner, extremely small ramus. Length of female 3.20 mm.

Remarks.—In the comparatively robust form of the body, this new species somewhat resembles the South American form *B. brasiliensis*, Lubbock, as recently described by Messr. Poppe and Mrázek. It is, however, of much larger size and, moreover, differs rather markedly in some of the anatomical details. From *B. triarticulata* it is also very easily distinguishable.

Description of the female.

The length of the body, measured from the front to the tip of the caudal lamellæ, is 3.20 mm., and this species accordingly grows to a very considerable size.

The form of the body, as compared with that of *B. triarticulata*, is very robust, the anterior division being considerably tumefied, and more than twice as long as the posterior one. Seen from above (fig. 1), the former division exhibits an oblong subfusiform shape, the greatest breadth occurring somewhat in front of the middle, and almost equalling half the length. Anteriorly it terminates in a narrowly rounded frontal part, whereas posteriorly it is but slightly attenuated. As in other species, this division exhibits 6 well-defined segments, the 1st of which is much the largest, equalling in length the 4 succeeding segments combined. At the sides of this segment, the 2 pairs of antennæ and to some extent also some of the oral parts are seen to project. The last segment is deeply emarginated in the middle, and is produced on each side of the emargination to a lamellar expansion pointing backwards and extending somewhat beyond the 1st caudal segment. As in *B. triarticulata*, these expansions are each divided into 2 lobes, the outer of which is much the larger and of broadly lanceolate form, terminating in a sharp point, bent slightly outwards. The inner lobe is extremely small, appearing merely as a slight acute lappet issuing from the inner side of the outer lobe. In *B. triarticulata* these inner lobes are much more fully developed, and the outer lobes rather narrow, mucroniform, and considerably divergent.

The tail is comparatively short, not nearly attaining half the length of the anterior division, and, as usual, is much narrower. It is divided into 3 well-defined segments, the 1st of which, the genital segment, is much the largest, and somewhat irregularly dilated in the middle, exhibiting below a rounded prominence, to which the egg-bag, when present, is attached. The last segment, which about equals in size the penultimate one, is somewhat dilated distally, and exhibits at its end the anal opening, partly covered above by a semilunar ridge. To this segment the caudal lamellæ are attached. They are comparatively larger than in *B. triarticulata,* attaining about the length of the last 2 segments combined, but otherwise they exhibit much the same appearance, having each 5 strong and densely plumose marginal setæ, and also at the inner corner above, a simple bristle.

The eye is rather small, though distinct, being placed, as usual, at some distance from the front and nearer the ventral than the dorsal face.

The anterior antennæ (see fig. 1) are comparatively shorter than in the New Zealand species, scarcely exceeding in length the anterior division of the body, and they are divided into the usual number (25) of articulations.

The posterior antennæ, the oral parts and the 4 anterior pairs of legs in their structure agree, on the whole, perfectly with those parts in *B. triarticulata,* and need not therefore be described in detail.

The last pair of legs (fig. 2) are also constructed in a very similar manner, being, like the preceding pairs, natatory, though differing from them in some points. The outer ramus is rather robust and, as in the other known species, has the 2nd joint produced inside to a strong conical process, coarsely denticulated on both edges. The terminal joint of this ramus is comparatively smaller than in *B. triarticulata,* being scarcely as long as the preceding joint, and very much narrower. It is, however, armed with the same number of spines, viz., 7, 2 of which issue from the outer edge, 3 from the inner, and 2 from the tip; of the last the outer one is much the larger and considerably stronger than any of the others. The inner ramus is but little more than half as long as the outer, and much narrower. Of its 3 joints, the terminal one is comparatively much smaller than in *B. triarticulata,* and carries only 5 setæ, whereas 6 such setæ are found in the said species. On the other hand, the 2nd joint has an additional seta inside, not found in *B. triarticulata.*

The adult male is somewhat smaller than the female, and exhibits the same difference from it as that observed in *B. triarticulata,* being on the whole of much more slender form and having the last segment of the anterior division quite simple, without any lateral expansions. Moreover, the tail appears more elongated, and is divided into 5 well-defined segments, besides the caudal lamellæ.

The right prehensile anterior antenna (fig. 3) is constructed in a similar manner to that in the male of *B. triarticulata,* the movable terminal part being without any processes or spines and somewhat shorter than the adjoining tumefied part of the antennæ.

The last pair of legs (fig. 4), as in the other species of the genus, are transformed into strong grasping organs, both legs being nearly equally developed, and each terminating with a slender claw. In the right leg, the outer ramus is distinctly biarticulate and comparatively more strongly developed than in the left leg, where it is composed of a single joint only. In the right leg, moreover, the claw is more abruptly curved than in the left, the claw of which, on the other hand, is more elongated and exhibits outside, near the base, a small secondary spine. The inner ramus of the right leg is simple and conically tapering in its outer part, and carries at the base inside a small, curved bristle; that of the left leg is extremely small, knob-like, and attached to the inside of a projecting corner of the last joint of the basal part. Of the serrated lamella occurring in *B. triarticulata* inside this joint, no trace is found in the present species.

Occurrence.—Some specimens of this pretty species were found in a sample taken by Mr. Whitelegge from some pools near Sydney. It is most probable, that the species has also been observed by Mr. King, and regarded by him as a species of the genus *Diaptomus*. But, as no figures or descriptions are given of the 4 species he enumerates, it is impossible to decide to which of them it ought to be referred.

36. Boeckella minuta, G. O. Sars, n. sp.
(Pl. 8. figs. 5—7).

Specific Characters.—Body much more slender than in the preceding species, the anterior division exhibiting in female a narrow oblong or almost cylindrical form, with the front obtusely rounded; lateral expansions of last segment less fully developed, not nearly extending to the end of the 1st caudal segment, outer lobe short lanceolate, inner triangular. Tail nearly as in the preceding species, but with the caudal lamellæ somewhat smaller. Anterior antennæ rather elongated, equalling in length the whole body, excepting the caudal lamellæ. Last pair of legs in female, with the terminal joint of the outer ramus extremely minute, and only provided with 2 unequal apical spines; those in male of a similar structure to that in the preceding species, but with the inner ramus in both legs simple cylindrical. Body in both sexes highly pellucid and nearly colourless. Length of adult female 1.28 mm.

Remarks.—This additional new species is easily distinguishable both from *B. triarticulata* and *robusta*, being of very inferior size, and also differing in the much more slender body, the less fully developed lateral expansions of the last pedigerous segment in the female, and in the somewhat deviating structure of the last pair of legs in both sexes.

Description of the female.

The length of fully adult, ovigerous specimens does not exceed 1.28 mm., and this form accordingly is very inferior in size to any of the other known species.

The body is, on the whole, much more slender than in the preceding species, and in this respect also surpasses the New Zealand form. The anterior division exhibits, when seen dorsally (fig. 5), a very narrow oblong, almost cylindrical form, the greatest width scarcely exceeding $^1/_3$ of the length. Anteriorly it somewhat tapers towards the obtusely rounded front, whereas posteriorly it is scarcely at all narrowed. The lateral expansions of the last segment are not nearly so fully developed as in the 3 other species, and extend but little beyond the middle of the 1st caudal segment. They are each divided into 2 well-defined lobes, the outer of which is the larger, and of a short lanceolate form, whereas the inner is more triangular in shape.

The tail does not attain half the length of the anterior division, and has the caudal rami somewhat smaller than in *B. robusta,* not nearly attaining the length of the 2 preceding segments combined.

The eye is very conspicuous, the pigment being of a dark red colour.

The anterior antennæ (see fig. 5) are rather elongated, equalling in length the whole body, minus the caudal rami. They are composed of the usual number of articulations, and in the living animal are generally extended laterally, with a slight curvature at the base.

The last pair of legs (fig. 6) differ conspicuously from those in the other species in the poor development of the terminal joint of the outer ramus. This joint is extremely small and of a linear form, carrying only 2 apical spines, the inner of which is the longer. Otherwise these legs, as also the other appendages, exhibit the structure characteristic of the genus.

The adult male, as usual, is even somewhat smaller than the female, and differs from it in the usual sexual characters.

The last pair of legs (fig. 7) are on the whole constructed as in the other species, though, on a closer comparison, several minor differences may be found to exist. Thus, the last joint of the outer ramus of the right leg is comparatively narrower than in the preceding species, and on the left leg this ramus is somewhat attenuated distally, whereas in *B. robusta* it is on the contrary, dilated at the end. The inner ramus in both legs is simple cylindric, being somewhat larger in the right than in the left leg. In the latter, the last joint of the basal part projects inside to a sharp corner, but any serrated lamella, like that found in *B. triarticulata*, does not exist.

In the living state of the animal, the body is highly pellucid and almost colourless, admitting of some of the inner organs being pretty easily traced through the thin integuments. The ovisac in the female (see fig. 5) only contains a very restricted number of eggs of a pale greenish colour.

Observations.—Some few specimens of this form developed in one of my aquaria and were watched for about a month. They did not, however, multiply, though some of the females were ovigerous, and in the later part of the summer they wholly disappeared. In habits it agrees with *B. triarticulata*, moving about in quite a similar manner.

Occurrence.—The mud, from which this form developed, was taken by Mr. Whitelegge from a pond off Botany

Bay, near Waterworks Bridge. A rather considerable number of specimens of the same species were, moreover, picked up from a sample taken by that gentleman from ponds at Bourke Street and the Waterloo Swamps.

Trib. Cyclopoidea. Fam. Cyclopidæ.

Gen. **Cyclops**, Müll.

37. Cyclops australis, King.

Specific Characters.— ♀ Body moderately slender, with the anterior division oblong oval, tapering somewhat posteriorly; none of the segments extant laterally. Tail about $^2/_3$ as long as the anterior division, genital segment not attaining the length of the 3 succeeding segments combined, and moderately dilated in front. Caudal rami narrow, linear, not diverging, exceeding in length the last 2 segments combined, innermost apical setæ a little longer than the outmost, both being much shorter than the 2 median ones, bristle of the outer edge not far remote from the tip. Anterior antennæ scarcely exceeding in length the 1st segment of the body, and 12-articulate, 8th and 9th joints rather large. First pair of legs with both rami biarticulate, the 3 succeeding pairs with 3-articulate rami of normal structure; 4th pair with the outer apical spine of the inner ramus nearly as long as the inner. 5th pair of legs very rudimentary, the basal joint not being defined from the segment, though carrying the usual seta, terminal joint very minute, with a comparatively short apical seta and an extremely small lateral denticle. Length of adult female 2.20 mm.

Remarks.—Although Mr. King would seem to have comprised several species under the above name, I think I am right in restricting the specific denomination proposed by that author to the present species, all the other forms, with which I am acquainted, having turned out to be identical with well-known European species. The present species is a very distinct one, differing, so far I can judge, from all the other known forms. For want of room on the plates, I have not been enabled to give any figure of this form, but I hope, that the above diagnosis will suffice for easily recognizing the species.

Occurrence.—This form was found in 4 different samples, the localities of which are as follows: Waterloo Swamps, Centennial Park, waterholes at Bourke Street, and «Near Sydney». It was not hatched in my aquaria.

38. Cyclops albidus (Jurine).

Syn. C. tenuicornis, Claus.

A few specimens of this well-known European species were found in a sample from the Centennial Park.

39. Cyclops Leuckartii, Claus.

Numerous specimens of this form were picked up from 3 different samples, the localities of which are as follows: Centennial Park; Bourke Street; Waterloo Swamps; waterholes at Bourke Street.

40. Cyclops serrulatus, Fischer.

Found rather abundantly in 2 samples, the one from the Centennial Park, the other from the Waterloo Swamps. It also developed in great numbers in my aquaria.

41. Cyclops phaleratus, Koch.

Some specimens of this species occurred in a sample from the Centennial Park.

42. Cyclops affinis, G. O. Sars.

Very frequent in several samples: Waterloo Swamps; Centennial Park; Bourke Street; Waterloo Swamps; water-holes at Bourke Street; opposite the Rope Works; Near Sydney. It was also found in great abundance in my aquaria.

Explanation of the plates.

Pl. I.

Daphnia carinata, King.

Fig. 1. Typical form: ovigerous female, seen from left side; magnified 26 diameters.
» 2. Tail of same, more highly magnified.
» 3. *Var. intermedia*: female with ephippium, seen from left side; magnified 26 diameters.
» 4. *Var. magniceps:* ovigerous female, seen from left side; magnified 26 diameters.

Pl. II.

Simocephalus acutirostratus, King.

Fig. 1. Ovigerous female, seen from left side; magnified 24 diameters.
» 2. Anterior part of the body, more highly magnified (antennæ omitted).
» 3. Tail.

Simocephalus gibbosus, G. O. Sars.

Fig. 4. Ovigerous female, seen from left side; magnified 44 diameters.
» 5. Anterior part of body, more highly magnified (antennæ omitted).
» 6. Tail.

Pl. III.

Moina australiensis, G. O. Sars.

Fig. 1. Adult female, with the matrix greatly distended with embryos, seen from left side; magnified 62 diameters.
» 2. One of the antennulæ, more highly magnified.
» 3. Leg of 1st pair.
» 4. Extremity of tail.
» 5. Ephippium from left side.
» 6. Adult male, seen from left side; magnified 79 diameters.
» 7. Same, viewed from the dorsal face (rami of the antennæ not drawn).
» 8. Extremity of one of the antennulæ, highly magnified.
» 9. Prehensile leg of 1st pair.
» 10. One of the testes, with the efferent duct.
» 11. Zoosperms very strongly magnified.

Pl. IV.

Moina tenuicornis, G. O. Sars.

Fig. 1. Adult female, with the matrix distended by rather fully developed embryos, seen from left side; magnified 62 diameters.

Fig. 2. Another female, with winter-eggs and the ephippium in process of formation, viewed from the dorsal face (rami of the antennæ not drawn).
» 3. One of the antennulæ, more highly magnified.
» 4. Leg of 1st pair.
» 5. Outer part of tail.
» 6. Extremity of same, still more highly magnified.
» 7. Ephippium from left side.
» 8. Adult male, viewed from right side; magnified 95 diameters.

Pl. V.

Ilyocryptus sordidus, Lièvin.

Fig. 1. Adult female, with 7 lines of growth, seen from left side; magnified 102 diameters.
» 2. One of the antennulæ, more highly magnified.
» 3. Tail.

Chydorus Leonardi, King.

» 4. Adult female, seen from left side; magnified 120 diameters.
» 5. Tail of same, more highly magnified.

Chydorus globosus, Baird.

» 6. Adult female, seen from left side; magnified 104 diameters.
» 7. Tail of same, more highly magnified.

Pleuroxus inermis, G. O. Sars.

» 8. Adult female, seen from left side; magnified 104 diameters.
» 9. Tail of same, more highly magnified.

Pl. IV.

Alona Whiteleggei, G. O. Sars.

Fig. 1. Adult female, seen from left side; magnified 104 diameters.

» 2. Tail of same, more highly magnified.

Alona pulchella, King.

» 3. Adult female, seen from left side; magnified 104 diameters.

» 4. Tail of same, more highly magnified.

Alona abbreviata, G. O. Sars.

» 5. Adult female, seen from left side; magnified 124 diameters.

» 6. Tail of same, more highly magnified.

Alonella clathratula, G. O. Sars.

» 7. Adult female, seen from left side; magnified 124 diameters.

» 8. Tail of same, more highly magnified.

Camptocercus australis, G. O. Sars.

» 9. Adult female, seen from left side; magnified 104 diameters.

» 10. Tail of same, more highly magnified.

Pl. VII.

Cypria pusilla, G. O. Sars.

Fig. 1 a. Adult female, seen from left side; magnified 45 diameters.

» 1 b. Same, viewed from above.

Trykt den 28de Juli 1896.

Cypris leana, G. O. Sars.

Fig. 2 a. Adult female, seen from right side; magnified 24 diameters.
» 2 b. Same, dorsal view.
» 2 c. Caudal ramus, more highly magnified.

Cypris lateraria, King.

» 3 a. Adult female, seen from right side; magnified 45 diameters.
» 3 b. Same, dorsal view.
» 3 c. Caudal ramus, more highly magnified.

Ilyodromus ellipticus, G. O. Sars.

» 4 a. Adult female, seen from right side; magnified 45 diameters.
» 4 b. Same, dorsal view.
» 4 c. Caudal ramus, more highly magnified.

Cypridopsis minna, King.

» 5 a. Adult female, seen from left side; magnified 45 diameters.
» 5 b. Same, dorsal view.
» 3 c. Caudal ramus, more highly magnified.

Candonopsis tenuis, Brady.

» 6 a. Adult female, seen from left side; magnified 45 diameters.
» 6 b. Adult male, in the same aspect and with the same magnification.
» 6 c. Same, dorsal view.
» 6 d. Caudal ramus, more highly magnified.

Pl. VIII.

Boeckella robusta, G. O. Sars.

Fig. 1. Adult female, viewed from the dorsal face (left antenna not fully drawn); magnified 35 diameters.
» 2. Same, leg of last pair, more highly magnified.
» 3. Right prehensile antenna of male.
» 4. Last pair of legs of same.

Boeckella minuta, G. O. Sars.

» 5. Adult, ovigerous female, viewed from the dorsal face (right antenna not fully drawn); magnified 68 diameters.
» 6. Same, leg of last pair.
» 7. Last pair of legs of adult male.

SKILBOTN

ET BIDRAG

TIL

KUNDSKABEN OM STRANDEROSION

AF

PETER ANNÆUS ØYEN

KRISTIANIA

ALB. CAMMERMEYERS FORLAG

LARS SWANSTRØM

KRISTIANIA — CENTRALTRYKKERIET 1896.

Skilbotn.

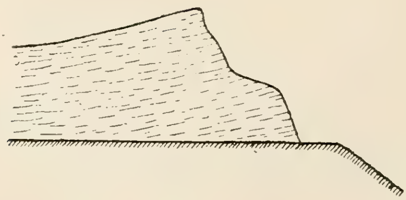
(Et bidrag til kundskaben om stranderosion.)

Af

Peter Annæus Øyen.

Oppe paa Helgelands kyst skjærer Skilbotn sig fra den for sin Torghat bekjendte Torgø i nordøstlig retning ind i landet over mod Velfjorden. Af mere fremtrædende punkter har man her inde paa fastlandet Trælnæshatten i syd og Moakslen i nord. Helt nede fra havet i sydvest har Skilbotn en ganske flad, svagt stigende dalbund op til den halvcirkelformede begrænsning mod nordøst. Nede paa den flade dalbund helt ind under de noksaa brat opstigende fjeldsider har man her Skaaren i en høide af 45 m. o. h. Foruden de to før nævnte fjelde i syd og i nord bør man mærke sig Ramtind i ost og i vest Tilrumshatten, hvis sydligste del, Havlarstuva, har en høide af 175 m. o. h. De fjeldrygge, som mere eller mindre sammenhængende forbinder de nævnte fire toppe, udgjør den tidligere anførte begrænsning i nordvest, nordøst og sydøst; den nogenlunde regelmæssige udvikling lader Skilbotn fremtræde som en smuk, vid fordybning, der paa grund af de to fra sydvest indgaaende fjordarme, Skilbotnfjord i sydøst og Trælvikosen i nordvest, faar fuldstændig karakteren af en fjordbotn. Mellem Skilbotnfjord og Trælvikosen hæver sig en lav, langstrakt fjeldryg, Aunheien, der som selve botnen har sin længdeudstrækning fra nordøst til sydvest. Aunheien har præg af et i stor maalestok montonneret klippeparti med stødsiden mod nordøst.

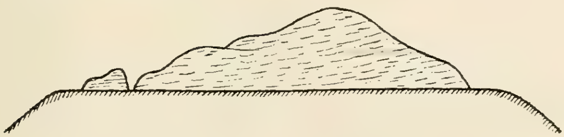
Paa Tellef Dahlls geologiske kart over det nordlige Norge er, naar undtages en liden som glacialt eller postglacialt betegnet strimmel, det hele herhen hørende parti betegnet som cambrisk, en afdeling, der jo forøvrig i petrografisk henseende er meget heterogen, men dog hovedsagelig bestaar af forskjellige krystallinske skifere. Af Corneliussen[1]) er bergarterne inden dette omraade henregnet til den af ham indførte «glimmerskifer-marmor-formation». Jeg har ved en tidligere anledning[2]) meddelt endel geologiske iagttagelser fra dette strøg, og den mikroskopiske undersøgelse har vist, at det væsentlig er glimmerskifere, snart med biotit, snart med muscovit, man her har for sig; overgange findes til klorit- og kvartsskifere. I det store og hele synes strøgretningen at være nordøstlig, faldet steilt; men herfra kan dog paavises større og mindre uregelmæssigheder. Et karakteristisk træk turde fremhæves i de flere hinanden skjærende lithoklassystemer.



Naar man fra et nogenlunde fritliggende sted, som f. ex. Havlarstuva eller endnu bedre den store afsats i Ramtinds sydvestlige del, lader blikket glide ud over Skilbotn, saa vil en paafaldende skarp og sammenhængende linje udhæve sig rundt botnen helt fra den sydlige del, Skilbotnfjordens sydøstlige side, over til Havlarstuva i vest. Det viser sig endvidere, at den nævnte linje falder ind i hoide netop med den ovenomtalte afsats i Ramtind. Denne afsats ligger her 110 m. o. h. og viste sig at være en gammel strandlinje i fast fjeld; det er altsaa tydeligvis et mærke efter en tidligere havstand, man ser tegne sig rundt botnen — en slutning, som detailundersogelsen fuldstændig bekræftede. Imidlertid vil man allerede med det blotte øie opdage enkelte afvigelser, som ogsaa maalingerne antyder, endskjønt de kun er anstillet med aneroidbarometer; men disse afvigelser er dog ikke saa store, at de paa nogensomhelst maade berettiger udskillen af flere særskilte niveautrin.

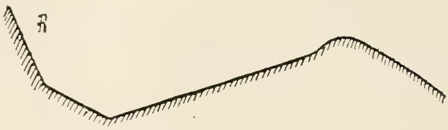
Saaledes ser man f. ex. i Skilbotns sydlige del paa sydøstsiden af Skilbotnfjord etsteds tre forskjellige, men hinanden ganske nærliggende trin; jeg fik dog ikke her anledning til at anstille noiere undersøgelse paa stedet.

Mod syd ser man fra Ramtind et inde i botnen opragende mindre fjeldparti, der ganske skematisk er gjengivet i følgende skisse:



Den udprægede linje, der omkranser partiet, er en tydelig afsats, som falder ind netop i høide med den linje, der nogenlunde sammenhængende strækker sig langs hele Skilbotns sydøstlige side. Dette fjeldparti har altsaa i sin tid været en mindre opragende ø i lighed med de mange, man nu har anledning til at se langs den norske kyst. Ved den ene ende ser man en liden opragende knat adskilt fra den større; dette er altsaa et forhold fuldstændig analogt med, hvad man f. ex. ogsaa har anledning til at iagttage ved Leka i den saakaldte Lekamo (cfr. afbildning, pag. 15 i Mohn's afhandling[3])).

Som allerede før nævnt ligger den store afsats i Ramtind 110 m. o. h. og fremtræder meget tydelig som en gammel strandlinje, til og med i fast fjeld. Selve strandlinjen fremtræder her som en større, ialfald efter øiemaal at dømme horizontal flade. Til orientering vedfoies en skematiseret skisse:



I den ydre kant rager fast fjeld op over fladens midlere niveau. De saaledes opragende fjeldknauser viser et tilsyneladende montonneret præg; men der fandtes ingen typisk glaciale skuringsstriber, ligesom heller ikke stød- og læ-sidefænomenet traadte frem. Den afrundede form synes i dette tilfælde nærmest at maatte betragtes som resultatet af en kombineret vandskvulp- og drivis-indvirkning. Jeg har ved en tidligere anledning[4]) hentydet til et lignende fænomen nær den nuværende havstrand i nærheden af Torghatten; her var det imidlertid iøinefaldende, at kun bølgeslaget havde andel i dannelsen af den særegne form.

At knauser af fast fjeld saaledes rager op over strandlinjens flade synes ikke at være et saa sjeldent fænomen endda. Schiotz omtaler det samme fænomen fra Vagge og Hammerfest[5]); men man faar ingen oplysning, om de opragende partier var afrundede, skurede eller ei. De nævnte iagttagelser benyttes saa af Schiotz til argumentation mod drivistheorien for strandlinjers dannelse, til argumentation for denudation i ebbe- og flodtid[6]). Paa samme sted antyder da Schiøtz, at kystis maa tænkes som det exporterende middel. Naar man imidlertid betragter den afbildning, som Reusch giver af strandlinjen ved Vagge[7]), saa er det indlysende, at ialfald paa dette sted maa en undersøgelse af erosionsfænomenet gaa forud for de opragende partiers anvendelse som bevis mod udskuring ved is. I Stygfjeld og Grubefjeld siger Hansen, at «de som holmer opstikkende skikthoveder i seten selv er afrundede» [8]).

Keilhau[9]) og med ham senere Pettersen[10]) og Hansen[11]) antog jo, at strandlinjerne var udgravet af svømmende isflag, og det vilde visselig være at forbise selve kjendsgjerningerne at fradømme denne theori enhver betydning. De afrundede, opstikkende fjeldpartier i strandlinjerne kan saa langt fra benyttes som bevis mod drivistheorien, at de tvertimod er et meget sikkert mærke efter isens skurende indflydelse. Det er forresten mærkelig, at man her stilles ansigt til ansigt med en modbevis- og bevisførelse, der er fuldstændig analog med en tilsvarende med hensyn til roches moutonnées, for hvis vedkommende jeg kun henviser til min tidligere diskussion af samme[12]). Naar man videre har søgt at rykke i marken med beviser, hentede fra analoge forhold ved den norske kyst nufortiden, som f. ex. Pettersen[13]), saa er dette vistnok en fuldstændig rigtig fremgangsmaade; men efter alt, som foreligger, tilhører jo de høitliggende strandlinjer langs Norges kyst en tid mere arktisk end nu, ja «the date of these rock-terraces probably goes back into the glacial period» [14]), og det bliver derfor ogsaa mere tilsvarende at hente de analoge beviser fra nuværende arktiske egne. Feilden og de Rance omtaler havisskuring fra Smith's Sound[15]), og jeg har selv i Smeerenburg Bay

(Spitzbergen) havt anledning til at se, hvilke ismasser en arktisk strøm kan sætte i bevægelse, hvorledes disse masser af drivis kan presses sammen, drives mod land og forsvinde for atter at give plads for nye skurende masser — det vilde være i høi grad besynderlig, om de ikke skulde sætte sit mærke paa kysten, ja til og med et betydeligt mærke, forudsat at kystlinjens forskyvning var forholdsvis langsom.

Men man opholder sig heller ikke længe ved en arktisk kyst, før man faar erfaring for, at ogsaa andre faktorer er virksomme i det nuværende strandbelte: det er den af hyppig temperaturveksling foraarsagede forvitring, som træder sterkt frem. Det siger sig selv, at hvor flod og ebbe gjør sig gjældende i udpræget grad, vil denne forvitring træde endnu sterkere frem, et forhold, som Blytt[16]) trak i forgrunden med hensyn til strandlinjers dannelse.

Man vil visselig finde, at flere forskjellige faktorer er medvirkende ved dannelsen af strandlinjer, snart træder en, snart en anden mere i forgrunden. Men til at forklare strandlinjefænomenet i sin almindelighed langs den norske kyst maa jeg erklære mig enig med Geikie, «that they may have been due in large measure to the effects of the freezings and thawings along the cold «ice-foot», and to the rasping and grating of coast-ice»[17]). Jeg vil i det følgende faa anledning til efterhaanden at omtale enkelte af de mindre fremtrædende faktorer, der ofte er af rent lokal natur.

I strandlinjen under Ramtind var selve fladen ca. 39 meter bred og dannedes for en stor del af myr og mosebund. Ved den indre væg var der nederst en mindre ur, der sikkerlig skyldtes recent denudation; denne maatte forresten begunstiges i betydelig grad derved, at fjeldet ved R. er meget gjennemsat af lithoklaser.

I den steile fjeldvæg ved R. lykkedes det mig at finde tydelig vandslidt overflade, karakteriseret ved det glatte udseende, den uregelmæssig buklede og lappede overflade og talrige smaa udskulpede erosionshuler. De mærker, som vandskvulpet saaledes præger fjeldoverfladen med, er saa karakteristiske og er af en saa stor betydning, at det synes mig fuldt ud berettiget for dette erosionsfænomen at indføre en egen benævnelse. Man gjenfinder det i huler, man gjenfinder det i strandlinjer — overalt er dette karakteristiske fænomen paa sin side et ligesaa godt mærke som de isslidte og vindslidte paa sin. Man vil derfor ogsaa finde, at ved studiet af littoralbeltets erosionsfænomener har ogsaa dette spillet sin rolle.

Senft gav saaledes f. ex. en ganske træffende, men kort karakteristik af dette fænomen[18]). Reusch foreslog for dette erosionsfænomen benævnelsen «polstret Fjeld»[19]), en benævnelse, som derpaa af Baldauf ganske kritikløst blev overført i den tyske literatur som «gepolsterte»[20]), men synes forresten ikke at have vundet nogen videre indgang. At denne benævnelse «i Lighed med det velkjendte Roches moutonnées for det isskurede Fjeld»[21]) staar langt tilbage for sidstnævnte i træffende karakteristik, springer meget snart i oinene; thi man kan trygt sige, det er meget sjelden, «Udseendet minder — — — om en udstoppet Ryg i en Sofa eller en Lænestol»[22]) — overfladen har ikke det regelmæssige præg. Man finder derfor ogsaa de to strandlinjeforskere Hansen og Pettersen kun tale om «den eiendommelige avglatning, polering»[23]). Penck gav ganske nylig en udførlig og træffende karakteristik af fænomenet, men har ikke fundet sig beføiet til at anvende nogen særegen benævnelse[24]).

Jeg har havt anledning til at undersøge dette erosionsfænomen paa flere forskjellige steder, seet det optræde i forskjellige former, alt efter de forskjellige forhold. I Sjonghelleren fandt jeg den vandslidte overflade meget hemmet i sin udvikling af de i gneisen optrædende talrige lithoklaser. I Torghattens gneisgranit viste hullets vægge paa flere steder typisk skvulpeslidt fjeldoverflade. I en tildels mere udvisket form finder man det samme fænomen i de af glimmerskifer bestaaende vægge i Havlarsholet og Monsen, hvorom mere senere. Det synes idethele at være de mere haarde og massive bergarter, som leverer de mest typiske former. Talrige lithoklaser hemmer den typiske udvikling, idet den almindelige forvitring træder sterkere i forgrunden; det samme synes i høi grad at være tilfældet ogsaa ved mere skifrige og løse bergarter, endskjønt man her paa sine steder kan finde meget typiske former, naar den senere denudation ikke har traadt for sterkt i forgrunden.

At finde en benævnelse, der paa sin side med hensyn til de vandslidte former med alle de forskjellige varianter indebærer et saa adækvat udtryk som den af Saussure[25]) for de isskurede former indførte, er meget vanskelig, for ikke at sige umulig.

Glatte, afrundede i smaa som i store træk fremtræder de vandslidte former med en overflade af et snart mere lappet, snart mere buklet udseende, der ofte faar et nervet og arret præg ved de talrige snart aareformede fordybninger, snart mere kopformede eller skaalformede huller af større eller mindre dybde, med mere ovalformede gjennemsnit eller mere kredsrunde, hvorved de ofte faar et rent jettegrydeudseende. Skulde man for disse meget vekslende erosionsformer, hvor ikke det regelmæssige præg spiller hovedrollen, men det uregelmæssige, optage nogen fælles sammenbindende benævnelse, saa vil jeg foreslaa: «*roche reniforme*» *).

Naar jeg her har foreslaaet indført denne benævnelse, saa har jeg ikke forbiseet, at Reusch ved en tidligere leilighed har brugt udtrykket «nyreformet overflade» i følgende skildring fra Bømmeløen: «Granitlandskabet ligner, hvad dets almindelige karakter angaar, meget den af augitsyenit bestaaende egn ved Fredriksværn. Man har for sig en utallighed af smaarygge og smaaknauser. Deres sider er bratte; oventil er de afrundede med lave bukler, hvorved en slags «nyreformet overflade» fremkommer. Grunden til disse klippeformer maa antagelig søges i en forud for isskuringen gaaende forvitring»[26]). Det fremgaar af den orografiske skildring, at man i det af Reusch behandlede fænomen har med et ganske andet at gjøre, for hvilket den nævnte betegnelse maa ansees for mindre adækvat, og jeg skal ved denne anledning ikke gaa nærmere ind derpaa — det er af mere orografisk karakter.

Roche reniforme er et bevis for, at brændingen har gjort sig gjældende som erosionsfaktor i littoralbeltet. Studerer man imidlertid dette fænomens optræden meget nøie, vil man snart komme til det resultat, at om end brændingen har været medvirkende ved strandlinjernes dannelse, kan den dog ingenlunde, som flere forskere har antaget, forklare selve strandlinjefænomenets udvikling. Reusch fandt jo, at det faste fjeld mellem fjæremaalet og flodmaalet, saa høit som sjøsprøiten naar, var sterkt forvitret, tagget, medens det saavel lavere som høiere var afglattet eller almindelig

*) Af den lighed, som nyreoverfladen f. ex. hos hornkvæget ved sit uregelmæssig lappede, buklede og aarede udseende viser med den her omhandlede overfladeform.

forvitret[27]). Men det falder ikke vanskelig at paavise, at selve fjeldlegemets sammensætning og forhold forøvrig, de petrografiske og stratigrafiske eiendommeligheder ligesaavel som ikke at forglemme de tektoniske har spillet en stor, om end ogsaa kun lokal rolle ved erosionen i littoralbeltet — at de spiller en stor rolle i det nuværende, har jeg havt anledning til at iagttage paa mangfoldige steder af den norske kyst.

Kjerulf antog jo, at «Strandlinierne ere havets eget arbeide under strøm i flod og fjære»[28]), og betegnede dem ogsaa senere som «horizontale, af havbrynet indgravede mærker»[29]), men vedføier dog ogsaa Keilhau's forklaring[30]). Mohn[31]), Reusch[32]), Lehmann[33]) m. fl. betonede saa med større eller mindre styrke denne dannelsesmaade; men som jeg tidligere har udviklet, har man at betragte brændingen som en bifaktor i lighed med de forskjellige tektoniske forhold.

I Ilsvikens strandlinjer (Trondhjem), om hvilken Chambers allerede 1850 udtaler, at «not the least doubt can exist, that it is the effect of the working of the sea»[34]), lykkedes det mig ikke at finde sikkert *roche reniforme* — nu, jeg fik ikke anledning til at undersøge den hele linje; men det er dog tilstrækkelig til at vise den lokale forekomst af fra dette sted af Reusch omtalt «eiendommelig tilrunding af fjeldet — — — indgaaende kopformig jettegryde»[35]).

Naar Feilden og de Rance[36]) paa den ene side, Knutsen[37]) paa den anden med forskjellig anvendelse af «isfoden» (the ice-foot) trækker dels dennes passive og dels dennes aktive betydning frem i forgrunden for at forklare strandlinjedannelsen, saa tor det være, at deri er «isfodens» betydning overvurderet — det bliver efter den erfaring, jeg har fra Spitzbergen, kun det indledende, ikke det afsluttende arbeide, «isfoden» udfører; men den forbereder ganske naturlig i høi grad terrænet for den skurende drivis, der samtidig bliver den sterke, udjevnende valse. «Isfodens» store betydning for temperaturvekslingen er indlysende.

Man ser saaledes, at der foruden de to hovedfaktorer, drivisskuring og forvitring, ved strandlinjedannelsen ogsaa gjør sig gjældende flere bifaktorer, der imidlertid samtlige kun virker paa en mere underordnet maade og tildels kun rent lokalt.

Paa Skilbotns nordlige side fra Ramtind i øst over til det mellem Moakslen og Tilrumshatten liggende skar i vest ser man strandlinjen noksaa tydelig markeret, og i det nævnte skar selv ser man endnu nogle masser af løst materiale, som trods sin uregelmæssighed dog nærmest maa tydes som strandlinjeafleiringer. Ret op for Skaaren dannede saaledes linjen en betydelig afsats, ca. 103 m. o. h. — en sumpagtig mosebund dannede her for en stor del selve fladen, men efter alt at dømme var linjen selv skaaret i det faste fjeld.

Et karakteristisk træk ved fjeldet paa den nordlige side af Skilbotn er, at der umiddelbart over strandlinjen findes flere mindre botnformede fordybninger i fjeldmassen. Disse «botner» har et fra de glaciale forskjelligt præg — de har tildels en noget uregelmæssig form, og de tektoniske forhold viser sig at have spillet en betydelig rolle. Seet i forbindelse med huledannelsen eier disse botnformede fordybninger en betydelig interesse; thi igrunden saa er de intet andet end begyndende huledannelser; dette sidste forhold tydeliggjøres end mere derved, at den store huledannelse Monsen netop fortsætter ind i fjeldmassen fra en af de her optrædende fordybninger.

Trykt den 29de Juli 1896.

Paa Tilrumshattens østlige side følges saa spor af en strandlinje, der fortsætter videre langs Havlarstuva. I dennes sydlige del finder man ret ned for den mærkelige huledannelse Havlarsholet en noget større flade, der udgjøres af en med frodig græsvekst og frodig løvtræskov bevokset, sumpagtig myrstrækning i en høide over havet af ca. 112 meter.

I den vestlige side af Tilrumshatten derimod fremtræder ingen tydelig strandlinje; men derimod lykkedes det mig her at paavise et par andre mærker, som vel afgiver et ligesaa tydeligt bevis for den tidligere kystlinje. Paa et sted fandt jeg nemlig her i ca. 110 m. o. h. et par jettegryder ganske tæt ved hinanden, og det faste fjeld viste sammesteds et afrundet udseende, svarende omtrent til det før omtalte fra den ydre kant af strandlinjen i Ramtind. De to jettegryder var omtrent af samme størrelse: ca. 2 m. diameter og 1½ à 2 m. dybde, hvorved dog maa mærkes, at der ikke kunde paavises fast fjeld i bunden af nogen; i den nævnte dybde havde man i den ene græsklædt sandbund, i den anden omtrent en halv meter vand, under hvilket bunden syntes at bestaa af sand og løs sten. At man her har med stranddannede jettegryder at gjøre, antydes foruden ved det faste fjelds udseende ogsaa ved den ene grydes skraastilling. Jeg kan i denne forbindelse gjøre opmærksom paa, at det ofte ogsaa har sine vanskeligheder at afgjøre, hvad der er isskuret, og hvad der er vandskuret fjeld, naar de to erosionsfaktorer har virket samtidig eller overgribende i hinanden; jeg erindrer ingensteds at have seet saa illustrerende exempler herpaa som paa den ude i Kristianiafjorden liggende o Store Færder. Kommer saa drivisskuring til, saa vil naturligvis forholdet blive endnu mere kompliceret.

Jeg vil saa benytte leiligheden til at gjøre opmærksom paa et par andre strandlinjer fra ganske nærliggende steder.

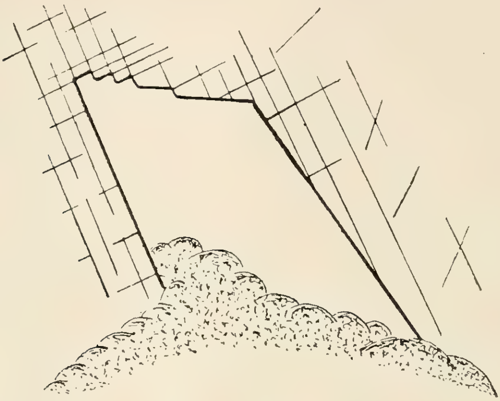
Paa sydsiden af den umiddelbart nord for Skilbotn indskjærende Velfjord har man en meget fremtrædende linje, der synes at have omtrent samme høide over havet som strandlinjen i Skilbotn. Jeg fik desværre ikke anledning til nøiere at undersøge denne langt sammenhængende og meget tydelige linje; da jeg kun har seet den fra fjordens nordside, er der jo en mulighed for, at det er et andet fænomen, man her har for sig. I den paa Velfjordens nordside som en ren fjordbotndannelse indskjærende Andalsvaag har jeg seet denne omkranset af en strandlinje væsentlig i løst materiale og, som det syntes, af omtrent samme høide som foregaaende; ellers kunde jeg ikke opdage spor af strandlinjedannelse paa Velfjordens nordside her i den ydre del.

Fra Trælnæshatten i syd har Reusch[38]) leveret en tegning med beskrivelse, hvorefter der skulde findes en afsats eller strandlinje paa dette sted, svarende i høide omtrent til den, jeg nu har beskrevet længere nord. Jeg har ved en bestigning af Trælnæshatten ikke kunnet overbevise mig om, at nogen strandlinje var udviklet paa dette sted. Derimod angav jeg ogsaa tidligere[39]), at Trælnæshatten syntes i sin helhed opbygget af forskjellige glimmerskifervarieteter, og jeg er derfor, indtil mere nøiagtige undersøgelser foreligger fra denne egn, tilbøielig til at anse de af Reusch optrukne meget uregelmæssige linjer ikke som littorale, men som stratigrafiske grænser.

Jeg skal derpaa gaa over til at levere en ganske kort beskrivelse af de to allerede i det foregaaende nævnte huledannelser: Monsen og Havlarsholet.

Monsen har i det store og hele retningen sydsydøst til nordnordvest med en temmelig vid aabning mod sydsydøst.

Hulen har her ved bunden en bredde af 28 meter og en høide, som jeg anslog til 20 à 25 meter, medens tversnittet forresten illustreres ved følgende tegning:



Hulens nordøstlige væg har en heldning paa ca 55°, medens den sydvestlige væg har en noget større heldningsvinkel, saa at hulen, som tegningen viser, tilspidses noget opad. Indgangen til hulen faar derved nogen lighed med Sjonghellerens. Hulens bund ligger ved aabningen ca. 124 m. o. h. Man har her en større ur, som ogsaa fortsætter videre nedover fjeldskraaningen Hulens tversnit, der som nævnt ved indgangen er temmelig stort, aftager efterhaanden indover og tilspidses inderst inde endog i den grad, at man ikke selv ved at krybe kan naa helt ind til den inderste mod nordnordvest liggende ende. Bunden er noget uregelmæssig, idet den ligger i forskjellig høide og snart dannes af sand, snart af større og mindre, skarpkantede blokke; men inderst inde har hulen samme høide over havet som ved aabningen. For at give en forestilling om hulens udseende og størrelse skal jeg vedføie nogle paa stedet tagne maal: 90 m. fra aabningen maaltes bredden 12 m. og 117,5 m. fra aabningen en bredde af 4,6 m. med efter øiemaal anslaaet høide ca. 8 m. Hulens hele længde er 137,2 m. Inde i hulen finder man helt indover til den inderste del væggene forsynet med de for *roche reniforme* karakteristiske erosionsheller; paa sine steder har dog atmosfæritierne øvet sin udviskende indflydelse. Har saaledes end brændingen utvivlsomt øvet sin indflydelse ved Monsens dannelse, saa fremgaar det allerede meget tydelig af den vedføiede tegning, hvor endel af de mest fremtrædende lithoklaser er angivet, at tektoniske forhold paa en meget iøinefaldende maade har gjort sig gjældende, et forhold, som end mere træder skarpt frem, naar man har anledning til inde i hulen at anstille mere indgaaende detailundersøgelser.

Havlarsholet er en af de mærkeligste huledannelser, jeg har seet. Fra den allerede før omtalte afsats (112 m. o. h.) i Havlarstuvas sydlige del fører en skraaning opover, og man er nu snart oppe i selve hulen, hvis bund er strøet med skarpkantede, mindre og større, tildels kjæmpemæssige blokke. Hulen, der strækker sig fra syd mod nord, har en temmelig vid aabning mod syd; men væggene trækker sig efterhaanden noget sammen mod nord, og bunden stiger, saa at hulen, om end rummelig, er noget trangere i den indre del, hvis bund ligger ca. 138 m. o. h. I den indre væg ser man endnu et par tilspidsede hulrum, der tildels er fyldt af nedfaldne, skarpkantede blokke. Inde i hulen finder man væggene udsirede med de eiendommelige erosionsfurer og erosionshuller, saa karakteristiske for *roche reniforme*. Denne huledannelse, der ikke udmærker sig saa meget ved sin længde, udmærker sig desto mere ved den omstændighed, at i den indre del en temmelig vid skakt, det egentlige Havlarshol, fører helt op i dagen, og det gjør et eiendommeligt indtryk at skue op gjennem den vide «skorsten», hvis tversnit, skjønt noget uregelmæssigt i form, kan sættes til ca. 10×6 m. Den høide, det her gjælder, vil man kunne danne sig en forestilling om, naar man erindrer, at hulens bund paa dette sted laa 138 m. o. h., og finder, at Havlarsholet kommer i dagen i en høide af 150 m. o. h., altsaa 15 m. under toppen af den til 175 m. o. h. opragende Havlarstuva. Heroppefra leverer den nedenforliggende græs- og skovklædte mark seet gjennem hullet et høist eiendommeligt skue. Tyder end det fundne *roche reniforme* paa brændingens arbeide og dens indflydelse paa huledannelsen, saa springer det meget snart i øinene, at paa dette sted har de tektoniske forhold øvet en afgjørende indflydelse. Man ser tydelig, hvorledes hulens kontur i alt væsentlig retter sig efter et omtrent horizontalt liggende og tre steiltstaaende lithoklassystemer; kun i mindre træk og udviskende har vandskvulpet ligesom de senere virkende atmosfæritier øvet sin indflydelse.

Ved de to nu beskrevne huler har jeg gjort opmærksom paa, at tektoniske forhold maa betragtes som den for deres udseende egentlig bestemmende faktor — at imidlertid ogsaa andre faktorer maa være traadt til, er indlysende, og af disse er allerede en omtalt. At senere forvitring har øvet sin indflydelse, er i denne forbindelse af mere underordnet betydning, hvor der er spørgsmaal om den egentlige genese. I denne forbindelse vil det imidlertid være nødvendigt at stille sig de huledannende kræfter overhovedet klart for øie.

Den store rigdom paa huler langs Norges vestkyst har tiltrukket sig megen opmærksomhed, og det allerede forholdsvis tidlig. Torghatten finder man saaledes f. ex. omtalt af Pontoppidan[40]), Hell[41]), Thaarup[42]). Neumann skrev sin

«Bjerg-Hulerne i Bergens Stift»[43]). Det vilde idethele blive et langt arbeide at gjennemgaa den hele række af denne klasse huler, og det vilde heller ikke høre hid — de staar alle i nær forbindelse med en tidligere marin grænse. Men foruden disse gives der en klasse huler, der gaar ind under det saakaldte karstfænomen, huler, som man ogsaa finder talrige repræsentanter for i Nordland. Af nogle gav Corneliussen saavel en geografisk[44]) som geologisk[45]) beskrivelse, ligesaa Vogt[46]); Vibe beskrev en eiendommelig huledannelse[47]) — erosion har ved disse huler været den bestemmende faktor; dog sees tydelig, at stratigrafiske og petrografiske, ja vel ogsaa tektoniske forhold har øvet sin indflydelse.

De to nu nævnte klasser af huler er hver paa sin vis eiendommelige — hver har de sin forskjellige dannelse. Det vil imidlertid være nødvendig at tage endnu et led i huledannelsen med, og paa den maade selvfølgelig se noget noiere paa en egen klasse huler. Reusch beskrev «En Hule paa Gaarden Njøs, Leganger Præstegjæld i Bergens Stift»[48]) og fandt, at «ingen af de Dannelsesmaader, man almindelig hører anføre for Hulers Vedkommende, passer her»[49]); men at det er «en ganske anden Dannelsesmaade — — —, Forf. tror at have kunnet læse ud af Forholdene paa Stedet: under et Jordskjælv er tidligere existerende Sletter blevne udvidede til Spalter; det opspaltede Fjeld er under Jordens Bæven knust, saaledes er Kløften, og hvor eiendommelige Forhold ved Sletternes Retning traadte til, den overdækkede Hule dannet»[50]). Den klasse huler, hvortil den her af Reusch beskrevne hører, er meget interessant; men den her angivne dannelsesmaade kan ingenlunde betragtes som væsentlig ny — det er i denne forbindelse tilstrækkelig at henvise til «coupe théorique, indoquant la manière dont

ont pu se former certaines cavernes par suite du refoulement, du plissement et de la dislocation des couches de la surface du globe»[51]). I Bykle (Sætersdalen) har jeg i Kværnhusaasens nordside selv havt anledning til at undersøge en huledannelse, der gaar ind under denne klasse. Fra Gauas dalføre beskriver Brøgger talrige sprækkedannelser og antager, «at mægtige Kræfter, ikke langsomt virkende Agenser»[52]) har frembragt dem. Imidlertid har det exempel, jeg anførte fra Bykle, antydet for mig, at man ved huledannelser af denne art ikke maa lade den af frostsprængningen betingede virkning for meget ude af betragtning.

Med de tre nu angivne forskjellige slags huler har man ihænde midlerne til nøiere at undersøge, hvilke de faktorer er, som især har været virksomme ved dannelsen af de huler, der i række følger efter hinanden langs kysten. Man kan gaa ud fra den sidstnævnte art, om hvilken man med Virlet kan sige, at «les causes premières de l'existence des cavernes sont les dislocations et les commotions successives de l'écorce du globe»[53]), og videre: «quand ces éboulemens se sont propagés jusqu'à la surface, ils y ont donné lieu à des espèces de cirques d'enfoncement»[54]) — (cfr. her hans tidligere «cirques d'enfoncement ou cavernes à ciel ouvert»[55]). Den anden art, karstfænomenets huler, interesserer i denne forbindelse kun forsaavidt, de viser erosionens betydning for huledannelser paa en tydelig maade. Endriss fandt saaledes, «dass zwischen dem Bau der Hohlräume und dem Bau der Spalten innige Beziehungen bestehen, dass die Spaltenzüge sozusagen die Grundlage für die Ausbildung des Höhlensystems abgaben»[56]); hvorimod Fraas fandt huledannelser, «die bald ausschliesslich auf Erosion zurückzuführen sind, bald aber auch mit localen Spaltenbildungen und Zerklüftungen des Gebirges in Verbindung gebracht werden können — — — Eine grössere tectonische Bedeutung als die localer Zerklüftungen wird sich aber wohl kaum herausconstruiren lassen»[57]. Og selv Virlet omtaler «cavernes qui se sont formées par simples érosions, commes celles qui se sont creusées le long des rivages de la mer, par l'action répétée des vagues»[58]. Tektoniske forhold og erosion spiller altsaa gjennemgaaende hovedrollen.

Torghattens hul er et meget instruktivt exempel fra den foreliggende egn. Mohn gav jo en beskrivelse af «Torghatten»[59] og gjorde opmærksom paa horizontal- og vertikalsletter samt en tidligere høiere havstand som momenter af betydning ved hullets dannelse. Ikke desto mindre finder man senere Kjerulf opstille sin bekjendte dislokationstheori for Torghatten og Kinnekloven[60]. Reusch fandt jo som regel for huledannelsen, at hulerne dannes paa spalter[61], at spalter og sletter er det bestemmende for deres form[62], at de er «et Værk af Havet»[63], og udtalte specielt om Torghathullet, at det «engang er dannet ved Brændingens Arbeide — — — paa et Sted, hvor der optræder Spalter, som netop der maa have lettet Bølgeslagets Virksomhed»[64]. Sollas betragtede ogsaa Torghathullet som «a sea-cave excavated between two master-joints» og udtalte videre, at «the joints are the most important factors in denudation»[65]. Jeg henviste ved en tidligere anledning[66] for Torghathullets vedkommende til de optrædende slettesystemer og havbølgernes tærende og udmeislende indvirkning.

De huler, der som de to af mig her beskrevne optræder langs den marine grænse, maa betragtes som en flerhed af andre huler væsentlig betinget i de tektoniske forhold, hvorpaa saavel deres forekomst som udseende tyder — det er de rent lokale forhold, ikke de mere generelle, som har været det bestemmende. Er end dette paa en vis maade en passiv betingelse, er den i dette tilfælde ikke desto mindre af stor betydning. Som eroderende har man bølgeslaget; derfor har man bevis i *roche reniforme* og i hulernes lithorale forekomst. At saa foruden disse to hovedfaktorer flere af mindre betydning spiller ind med, maa ikke forbisees: seismiske virkninger kan have øvet sin indflydelse ligesaavel som atmosfæritierne ved senere indvirkning — den af temperaturveksling betingede forvitring maa ikke glemmes, ligesom for de høitliggende hulers vedkommende kystis kan have spillet en rolle som transportmiddel.

Reusch angiver, at man ingen sikkerhed har for, at de havdannede huler tilhører samme tid ifølge sin dannelse som de øvrige vandstandsmærker[67]). Da jeg nu i Skilbotn inden et forholdsvis snevert omraade imidlertid har paavist strandlinjer i fast fjeld og i løst materiale, havdannede jettegryder og *roche reniforme*, havdannede «botner» og huler — alt i nær samme niveau, forekommer det mig, at man ialfald paa dette sted har med samtidige dannelser at gjøre. At hulerne ligger noget høiere end strandlinjen, er et noget afvigende forhold, som jeg senere skal komme tilbage til. Naar Reusch imidlertid opstiller følgende trinfølge: «Huler, Tunneler, Kløfter, Skar, Sund»[68]) for de littorale erosionsfænomener, saa maa jeg gjøre opmærksom paa, at denne trinfølge ingenlunde maa opfattes for bogstavelig — de stranddannede «botner» antyder, at trinfolgen ogsaa tildels kan blive en anden, idet de to første led overspringes.

Strandlinjer og huledannelser gav i Skilbotn ligesom ogsaa ellers paa Norges vestkyst et umiddelbart indtryk af at være ny i forhold til selve egnens konfiguration. Naar man ser saadanne over strandlinjen opragende kupper som Torghatten, Sverresborg, Bremnæshatten og den foran aftegnede syd for Ramtind, bestyrkes endnu mere denne opfatning. Det skulde forsaavidt ikke her være nødvendig at komme tilbage til den af Sexe opstillede glaciale theori for strandlinjernes dannelse[69]), efterat Hansen havde givet sin træffende kritik af den[70]), hvis man ikke selv ganske nylig havde fundet en efterdønning — Rekstad antager nemlig, «at en isbræ har gaaet ud efter fjorden, medens dens mægtighed ikke har været stor nok til at fylde den ganske. Den vilde da blive horizontal og følgelig have horizontale sidemoræner»[71]). Efter det kjendskab, jeg har saavel til nu existerende bræer som til tidligere existerende bræers afleiringer, er imidlertid det af Rekstad førte tankeexperiment ikke stemmende med de kjendsgjerninger, som de virkelige forhold frembyder; kunde de end til en vis grad tænkes mulige for de i løst materiale optrædende linjer, saa er det i ethvert fald aldeles utænkelig for de i fast fjeld optrædende. Men man vilde i dette tilfælde selv for de i løst materiale optrædende linjer efter Rink's[72]) og Hellands[73]) fremstilling ikke have med en isbræ at gjøre, men med de fra bræen løsnede blokke og paa den maade være kommet tilbage til selve drivistheorien. Sexe angav jo, «at der paa det omkring 300 Fod høie Klippeparti mellem Dybdal og Mundal fandtes Skuringsmærker fra Istiden baade der, hvor Linien siges at ligge, og ovenfor og nedenfor samme», og anfører saa videre: «Paa Grund af disse Skuringsmærker kan den omhandlede Strandlinie ikke være frembragt efter Istiden»[74]). Som det vil fremgaa af, hvad jeg har meddelt om strandlinjen i Ramtind, maa man være meget forsigtig med hensyn til de spredte skuringsmærker, man iagttager i strandlinjer — deres forekomst og udseende maa studeres særlig omhyggelig; dette har jeg seet et udmærket exempel paa i Aardalsfjord (Ryfylke); i denne forbindelse kan ogsaa henvises til de Skuringsmærker, man ofte finder i det nuværende littoralbelte. Denne Sexe's iagttagelse kan derfor ikke tillægges nogen afgjørende betydning, da det sandsynligvis er drivisskuring, som i dette tilfælde er forvekslet med glacialskuring. At de strandlinjer, der her er tale om, er af sen glacial eller postglacial alder, tør ansees som sikkert. Thi selv om man gik til den extreme yderlighed at benægte en isbræes erosionsevne, at man tvertimod ansaa isbræen som konserverende, og paa den maade kunde forsvare den preglaciale existence af strandlinjer i fast fjeld, saa vilde det dog være aldeles umulig at hævde en saadan opfatning med hensyn til de linjer, man finder i løst materiale; men man er udentvivl berettiget til at betragte begge de nævnte arter linjer som samtidige dannelser.

I denne forbindelse kunde det være værdt at se lidt paa den, hvortil strandlinjer findes paa den heromhandlede kyststrækning mellem 65° og 67° n. br. For at begynde i syd har man Mohn's angivelse af en horizontal linje paa sydsiden af Leka 340′ og en horizontal linje paa nordsiden af Leka 341′[75]). Torghattens aksler angives af Mohn til 347′ o. h.[76]). Torghathullet ligger derimod med sin bund 123 og 144 m. o. h.[77]). I det foregaaende er strandlinjerne fra Skilbotn og Velfjord omtalte. I den indre del af Vefsenfjord angav jeg den høieste strandlinje til 107 m. o. h. og flere lavere terrasser[78]). Fra Mosjøen har jeg seet terrasseformet anordnede grusmasser i syd, men jeg fik ikke anledning til nøiere at undersøge dem; skulde det vise sig, at man her har for sig virkelige terrasser høiere end det fra Vefsenfjorden nævnte, er det sandsynlig, at netop paa grund af landets eiendommelige konfiguration særegne glaciale forhold her har gjort sig gjældende, saa at man istedetfor marine terrasser faar saadanne, der skriver sig fra opdæmmede indsoer — alt dette bliver det imidlertid en detailundersøgelses-sag at udrede. Fra Tomøen angiver Mohn en strandlinje paa østsiden 301′ o. h.[79]) og Corneliussen en huledannelse paa nordvestpynten 87 m. o. h.[80]). Rekstad angiver fra Holandsfjord strandlinjer ved Rendalsvik (102 m. o. h.), Enga (102 m. o. h.), Braset (98 m. o. h.) og Holand (50 m. o. h.)[81]); hans forklaring af «strandlinjedannelsen» paa dette sted har jeg før gjort opmærksom paa. Strandlinjerne i Holandsfjord har imidlertid allerede Geikie tidligere gjort opmærksom paa: «the Norwegian fjord has its sides marked by the line of a former sea-margin, about 250 feet above the present. This terrace winds out and in among all the ramifications and curves of the fjord»[82]). Og fra Fondalsbræ fortæller Geikie videre, at «the high terrace so marked along the sides of the Holands fjord enters this valley, and extends on the mountain sides as far as, at least, the foot of the glacier. Hence the gravelly plain and the moraine mounds that separate the glacier from the fjord are overlooked on either side by a raised sea-beach»[83]). Ved Glomfjorden omtaler Rekstad «en horizontal terrasse i en høide af omkring 75 m. o. h.» ved Vasdal — «dens udseende tyder paa, at det er en moræenedannelse», og ligesaa omtales ved gaarden Glommen «tvende terrasselignende moræner, den ene 66 m. o. h., den anden 108 m.»[84]). Efter Rekstads egen udtalelse skulde altsaa i dette tilfælde strandmoræner foreligge; den ubestemte beskrivelse giver heller ikke anledning til nogen bestemt slutning, skjønt høideforholdene taler sterkt for virkelige strandlinjer. Man ser altsaa, at der paa den omhandlede strækning af den norske kyst udhæver sig et ganske bestemt strandlinjeniveau i høiden 100—110 m. o. h. De forholdsvis faa og ikke absolut nøiagtige maalinger tillader ikke at drage nogen bestemt slutning med hensyn til linjernes horizontalitet eller ei. Under dette niveau følger da flere lavere. Et træk af særlig betydning er, at der ved flere huledannelser viser sig sikre mærker efter brændingens arbeide indtil omtrent 30 m. over den høieste strandlinje.

Ganske lignende forhold, som de nu her paapegede, finder man ogsaa paa andre steder, f. ex. i omegnen af Trondhjem. Chambers omtaler jo her «a terrace of erosion, on the face of the cliffy hill to the west of the city — — — it extends for miles along the face of the hill, at one uniform elevation», som han da ved nivellement bestemte til 522 «feet» o. h.[85]). Denne linje er saaledes ikke blot beskrevet og maalt efter den af Kjerulf angivne dato[86]), men ogsaa før. Jeg har ved et besøg paa stedet havt anledning til selv at undersøge en del af denne Ilsvikens berømte strandlinje, og Chamber's beskrivelse er meget træffende: «on near inspection, we find a deep cut into the almost horizontally disposed slate-rocks, with a ledge, flat though rough»[87]). Der findes imidlertid paa dette sted ikke blot en, men to linjer. Ilsvikens to strandlinjer blev beskrevet af Kjerulf[88]), deres høide af Mohn bestemt til respektive 512 og 569 fod[89]), og ved senere nivellement fandt kaptein Sejersted respektive 161,1 og 177,8 m.[90]). Mohn siger, at Ilsvikens strandlinje er horizontal, og at den nedre linje, hovedlinjen, viser sig horizontal i flugt med den horizontale afsats i Sverresborg[91]). Men i nærheden findes ogsaa en hel del lavere terrasser. Hugh Miller angav den øvre linje til 580 «feet» o. h., svarende til den i Norge almindelige «marine limit», og meddeler videre, at «above the Bay of Leangen, two miles east of town and river, and far beyond all erosive influence of the latter, thirty of these lines were mapped one above another in the first 300 feet of ascent — — — the number actually mapped was forty-three, or, with the two rock-terraces, forty-five», og Miller siger, at «these terraces are all post-glacial»[92]).

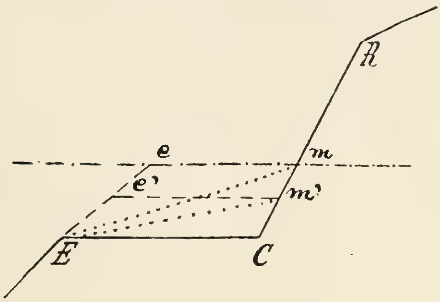
At man i det første af de her foreliggende tilfælde over selve hovedlinjen har huledannelser i en høide, der svarer omtrent til en mindre tydelig markeret strandlinje i det andet, antager jeg, er et forhold, der, skjønt mindre paaagtet, er af den største betydning for forstaaelsen af selve strandlinjedannelsen. Det viser ialfald med sikkerhed, at den høieste skarpt markerede strandlinje ingenlunde repræsenterer mærket efter den høieste vandstand. Naar saaledes Mohn inddelte strandlinjerne i flere grupper og hver af disse grupper igjen i flere niveauer[93]) og videre taler om «de tydelige Sprang mellem disse Niveauer»[94]), saa vil den foregaaende fremstilling tilfulde vise berettigelsen af en saadan adskillen; men den lader sig ikke derfor uden videre anvende paa de to her foreliggende tilfælde, der meget mere tyder paa, at de to nærliggende trin i dannelse væsentlig er at henføre til omtrent samme tid. Den egentlig strandlinjedannende kraft, drivisen, arbeidede under havfladens niveau, medens de forskjellige bifaktorer gjorde sig gjældende med større og mindre styrke i og over, naturligvis især mellem ebbe- og flodmaal. Derfor fik man egentlig et dobbelt mærke for hvert adskilt trin: øverst fik man mærke efter brænding og forvitring, der fik man utydelige strandlinjer og huler — men nederst skardrivisen, «a deep cut», der fremstod den egentlige strandlinje.

Jeg skal ikke ved denne anledning gaa ind paa det interessante spørgsmaal om strandlinjeforskyvningens kontinuitet eller diskontinuitet, om strandlinjen undergik en negativ forskyvning i sprang (Kjerulf[95]), Mohn[96])), periodisk (Hansen[97]), Schiøtz[98])) eller kontinuerlig (Blytt[99]), Pettersøn[100]). Henvisningerne kunde her forfleres; men de anførte vil være tilstrækkelige til at vise, at paa dette omraade vidt forskjellige anskuelser gjør sig gjældende.

Naar Schiøtz paa rent theoretisk grundlag fører et mathematisk bevis, hvis resultat er, at man ved en kontinuerlig forskyvning af strandlinjen ikke kan faa en horizontal strandlinjeflade[101]), saa er dette visselig fuldstændig korrekt, naar man gaar ud fra de forudsætninger, Schiøtz gjør. Men som det vil fremgaa af den foregaaende udvikling, maa man efter min mening tillægge drivisen en langt større betydning, end Schiøtz's forudsætninger gjør, og dertil kommer som en meget vigtig faktor den omstændighed, at strandlinjefladen, som jeg har gjort opmærksom paa, ikke dannes i, men under havfladen, et forhold, som Schiøtz ogsaa har været opmærksom paa, men tydeligvis ikke har draget fuldt ud konsekvenserne af[102]). Den følgende udvikling vil klargjøre forholdet tydeligere.

Geikie gav en skematisk fremstilling af et submarint plan (altsaa begyndelsen til, hvad Ramsay kaldte «a plain of marine denudation»[103])) med de tilsvarende littoraldannelser: huler, tunneler etc.[104]). Noget svarende til strandlinjer ser man ikke; Geikie's anskuelse om disse er tidligere anført. Den allerede før meddelte skematiske skizze af strandlinjen i Ramtind kan vistnok tages som en type paa et strandlinjetversnit — allerede selve tversnittet antyder, at den eroderende kraft ikke har virket udelukkende i samme horizontalniveau. Det er jo forholdsvis sjelden, man i strandlinjerne træffer det af Geikie fremstillede littorale erosionsprofil med den udoverhængende klippe over flodmaalet[105]). Reusch afbilder rigtignok et lignende forhold ved Ilsvikens strandlinje[106]); men jeg har selv havt anledning til at overbevise mig om, at selv ved Ilsvikens strandlinje er dette forhold ingenlunde det almindelige; det sandsynlige er, at man paa vedkommende sted har med rent lokale aarsager at gjøre — noget, man forresten ingen oplysning faar om.

For at anskueliggjøre forholdet ved strandlinjens erosion vil jeg fæste opmærksomheden ved følgende figur:



Lad *RCE* betegne tverprofilet af et strandlinjeindsnit i den oprindelige fjeldside *RE*.

Tænker man sig nu de eroderende kræfter begynde i *R* og erosionen fortsætte under strandlinjens negative forskyvning, samtidig med at de eroderende kræfter øges og naar sit maximum i *me*, saa vil i dette øieblik ifølge det foregaaende strandlinjens tverprofil ikke være *Rme*, men *Rme'*, hvor *e'm'* vil ligge desto dybere under *em*, jo sterkere isdannelsen i dette øieblik er. Fortsætter nu videre under strandlinjens negative forskyvning erosionen med aftagende kraft sit arbeide, saa skulde man ifølge Schiøtz[107]) faa profilet *RmE*; men ifølge det foregaaende vilde jo efter den samme fremgangsmaade resultatet være profilet *Rm'E* — altsaa en strandlinjeflade *Em'* med betydelig mindre heldning end *Em*. Det er imidlertid indlysende, at selv profilet *Rm'E* ikke er det endelige resultat, naar man efter

Trykt den 11te August 1896.

det i det foregaaende paaviste ikke alene har at betragte den almindelige denuation som en eroderende faktor, men efter kjendsgjerningerne at dømme maa tillægge drivisen en væsentlig betydning. Denne vil nemlig fortsætte sit arbeide omtrent ligelig over hele strandlinjefladen, saalænge kun denne flade befinder sig i tilstrækkelig dybde under vandfladen. Er imidlertid de eroderende kræfter aftaget i den grad, at de ikke kan holde skridt med strandlinjeforskyvningen, vil forholdet ganske naturlig blive et helt andet — da kan denudationen komme til at gjøre sig gjældende paa den af Schiøtz theoretisk udviklede maade — deraf den ofte ved *E* iagttagne afplatning af kanten.

Det er langt fra min mening paa denne maade at have indirekte paavist, at strandlinjerne maa være dannet under en negativ forskyvning af strandlinjen, da de nemlig kan være dannet under særegne forhold i de eroderende kræfters til- og aftagen. Men saa meget vil dog fremgaa af det nu udviklede, at strandlinjernes udseende ikke kan tages til indtægt mere for en theori om strandlinjens stilstand end for dens forskyvning under dannelsen — det bliver ganske andre forhold, som maa afgjøre, om der har gjort sig gjældende nogen periodicitet i strandlinjens forskyvning. Jeg antager ogsaa, at Schiøtz selv vil være den første til at indrømme, at ved strandlinjedannelsen saa mange forskjellige faktorer kommer til at spille sin rolle, at det vil være meget vanskelig at gjøre en rent theoretisk mathematisk betragtningsmaade exclusivt gjældende. Selve strandlinjedannelsen afgiver visselig endnu et særdeles rigt og interessant studiefelt.

I denne forbindelse, da nu engang spørgsmaalet om stranderosion foreligger, vil jeg ogsaa i korthed berøre et andet forhold, som slutter sig temmelig nøie hertil. Det var jo antaget, at den skandinaviske halvø steg, og i den anledning har man ogsaa paa den norske kyst anbragt endel vandstandsmærker. Naar man har villet knytte disse til tang- og balangrænsen (cfr. Storthings-Dok. No. 75 og Indst. No. 164 i 1893), saa maa hertil bemærkes, at disse to grænser optræder paa en saa uregelmæssig maade, influeret dels af de petrografisk-stratigrafiske forhold og dels af littoralerosionen, at de mærker, der er knyttet til disse grænser, ingenlunde kan benyttes med nogen sikkerhed til bestemmelse af strandlinjens forskyvning. Dette er et forhold, som jeg har havt anledning til i detaljerne at studere paa en stor del af Norges kyststrækning. Det er imidlertid indlysende, at her visse strømforhold ogsaa vil gjøre sig i høi grad gjældende, ligesom tidvandet øver en betydelig indflydelse.

Tidligere antoges det jo ganske almindelig, at strandlinjerne var dannede langs selve havkanten — i havets niveau. Imidlertid opstillede Suess sin «Gletscherabschlusstheorie»[108]), der saa af Sandler modificeredes derhen, at ogsaa glaciale afleiringer ved fjordmundingerne skulde have været medvirkende; men Sandler medgiver dog, at «eine Untersuchung von Fall zu Fall» maa afgjøre, om alle strandlinjer paa den norske kyst kan ansees dannede i saadanne opdæmmede indsøer[109]).

For den mellem Leka i syd og Støt i nord liggende del af den norske kyst kan imidlertid hverken den af Suess eller den af Sandler opstillede theori gjøres gjældende i sin almindelighed til at forklare strandlinjefænomenet — selvsamme strandlinjeniveau inde i de dybe fjorde og paa øerne ude mod det aabne hav er bevis nok.

Det ligger udenfor nærværende afhandlings ramme at gaa ind paa en nærmere diskussion af det lave forland, der optræder langs den norske kyst og i omegnen af Torghatten, optræder paa en meget typisk maade saavel ude paa øerne som inde paa fastlandet. Jeg skal kun i forbigaaende gjøre opmærksom paa, at «opdagelsen» af dette lave forland ingenlunde tilhører det sidste decennium, og at «the views — — — bear a very striking resemblance to a simple raised beach»[110]).

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Trykfeil.

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STRANDLINJER

I

GUDBRANDSDALEN

AF

PETER ANNÆUS ØYEN

KRISTIANIA
ALB. CAMMERMEYERS FORLAG
LARS SWANSTRØM

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Strandlinjer i Gudbrandsdalen.

Af

Peter Annæus Øyen.

Allerede fra gammel tid af synes bygdens folk at have været opmærksom paa de i Dovre og Lesje optrædende «Flaatte»; men disse har dog ikke her spillet en saadan rolle i den overleverede tradition som f. ex. «Munkevejene» i Trysil[1]) og «Fingalian Roads» i Lochaber[2]).

Den eiendommelige indflydelse, som disse setedannelser har saavel i rent topografisk henseende som paa jordsmonnet, har i disse bygder gjort sig gjældende paa en meget fremtrædende maade i selve bebyggelsen, og man sporer som paa flere steder indflydelsen selv i enkelte gaardsnavne. Allerede Chambers har været opmærksom paa dette eiendommelige topografiske forhold til bebyggelsen; thi han siger: «I could distinctly trace this terrace by its hummocks of water-laid sand, and the farmhouses perched on its favourable points. A long series of hamlets on the road to Molde is placed upon it» [3]).

Naumann, der reiste i Norge i aarene 1821 og 1822, siger om Dovre, at «sich im ganzen Thale Sand-Anhäufungen sehr bemerklich machen» [4]), og han omtaler ogsaa de optrædende setedannelser. Da Naumann's optegnelse synes fuldstændig glemt[5]), skal jeg hidsætte følgende: «Die ganze

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Thalstrecke von Bottem bis unterhalb Mölmen scheint einst das Bette eines groszen Sees gebildet zu haben, dessen Spiegel wohl sehr hoch über dem des Lessø-Werk-See lag. Nun findet sich aber nach jeder Seite ein gewaltsamer Durchbruch abwärts, der eine unterhalb Mölmen, der andere bey Bottem — — — Wenn man die Gehänge jenseits Bottem von einem hohen Standpunct diesseits mustert, so bemerkt man ein paar terrassenartige Zonen, die sich hier und da unterbrochen, horizontal am Gehäng hinziehen und auf Spuren der ehemaligen Ufer zu deuten scheinen. Wohl dürfte sich die Höhe der unteren dieser Zonen nicht viel vom jetzigen Niveau des Lessø-Werk-See abweichend ergeben»[6]).

Denne Naumann's iagttagelse af strandlinjer i den nordlige del af Gudbrandsdalen er selv i og for sig meget interessant, men bliver det i endnu høiere grad, naar man ser hen til den omstændighed, at den er gjort kun nogle ganske faa aar efter, at Mac Culloch ved offentliggjørelsen af sin afhandling «On the Parallel Roads of Glen Roy»[7]) i aaret 1817 havde indledet den senere saa livlige diskussion om disse, men dog fuldstændig uafhængig. Det er ligeledes meget interessant at se Naumann i dette tilfælde erkjende linjernes lakustrine karakter, ligesom Mac Culloch for linjerne i Glen Roy; men imidlertid synes ingen af dem at have dannet sig nogen bestemt forestilling om dæmningens karakter — dog synes tanken nærmest henledet paa grusophobninger.

For Lochaberlinjerne fremsatte saa Darwin i 1839 sin marine theori[8]), og det var derfor ikke andet, end man maatte vente sig, at denne theori ogsaa blev anvendt paa Dovrelinjerne, da disse senere blev undersogt af den marine theoris vigtigste forkjæmper, Robert Chambers.

Chambers gav derpaa 1850 ved to anledninger[9]) beskrivelse af Dovres og Lesjes strandlinjer og hævder ved begge linjernes marine oprindelse. «I discovered one,» siger Chambers, «of a much more remarkable character, passing along both sides of the valley for fully twenty miles, always at one elevation — — — As an object in physical geography, in its form, its uniform level on both sides of the vale, and its relation to the lake at the summit-level, this terrace precisely resembles the lowest of the Glenroy terraces as it approaches Loch Laggan» [10]). Dermed var den væsentlige lighed mellem disse to strandlinjeforekomster præciseret, og det falder derfor ganske naturligt, at studiet af dem senere for en stor del udvikler sig side om side.

Efter sammen med Buckland at have aflagt et besøg i Lochaber 1840 fremsatte Agassiz for de der optrædende strandlinjer sin glaciale theori, som derpaa er meddelt i en skrivelse til professor Jamieson. Da imidlertid denne skrivelse fra Agassiz til Jamieson synes glemt eller forbiseet [11]), skal jeg af den hidsætte følgende: «The existence of glaciers in Scotland at early periods can no longer be doubted. The parallel roads of Glen Roy are intimately connected with this former occurrence of glaciers, and have been caused by a glacier from Ben Nevis. The phenomenon must have been precisely analogous to the glacier lakes of the Tyrol, and to the event that took place in the valley of Bagne» [12]).

Det varede dog længe, før den glaciale theori vandt nogen anvendelse ved Dovrelinjerne. Kjerulf polemiserede rigtignok mod den marine theori; men hans standpunkt karakteriseres meget godt ved følgende udtalelse: «Hvad der netop her umiddelbart har sperret Bassinet, har man paa Stedet ikke let for at begribe» [13]), og denne forfatter syntes at blive staaende ved denne noget ubestemte opfatning, hvis man ikke skulde være berettiget til at trække en vis slutning af følgende, hvor talen er om terrasser: «i lukket situation — indenfor en fjeldsnævring, f ex. i et bassin» [14]), og hvor man finder Dovredalen opført som visende indlandsterrasser i lukket bassin [15]). Det er væsentlig den samme opfatning, som er gjort gjældende af Gumælius, der ogsaa beskriver Dovres terrasser som indsøterrasser og forklarer tømningen ved postglacial erosion i det trange pas Rosten [16]), og efter hans mening skulde jettegrydedannelse have været en væsentlig faktor ved gjennembruddet [17]).

Sommeren 1872 besøgte saa Dakyns Norge og skrev umiddelbart efter hjemkomsten til England sin afhandling «High-Level Terraces in Norway», som imidlertid ikke blev publiceret før i 1877 [18]). Her beskrives da strandlinjer fra Dovre og Lesje, og denne afhandling er saa meget mere mærkelig, som den glaciale theori her trækkes i forgrunden til at forklare fænomenet, idet Dakyns siger: «One is irresistibly led to think of the similar case of the parallel roads of Glenroy, and to speculate on this terrace too having been due to the waters of a gigantic Marjelen See, dammed back by ice till it overflowed the summit of the pass at Molmen; and it is significant that I could see no trace of terrace or water-mark on the Romsdal side of the pass» [19]).

Hugh Miller iagttog saa disse strandlinjer 1873, men først 1886 samtidig med at gjenkalde i erindringen Chambers's beskrivelse meddeltes en notits derom. Miller siger imidlertid selv, at han intet har at føie til de af Chambers gjorte iagttagelser. Miller taler om «the vanished sheet of water, in which they were formed»; men om det er den marine eller lakustrine theori, der skal støttes, fremgaar ikke med sikkerhed [20]).

Med ottiaarene begyndte en livligere diskussion af de skandinaviske seter. Det kan i denne forbindelse ogsaa mærkes, at Blytt 1880 saa en strandlinje paa Tønsæt og udtaler om samme: «Vielleicht ist dieselbe eine Süszwasserbildung aus der Eiszeit, vielleicht inter- oder präglacial»[21]). Högbom beskrev strandlinjer fra Jemtland[22]) og gav senere fortsatte bidrag til den samme egns strandlinjegeologi med hidhørende literaturoversigt[23]). Hansen gav 1885 en beskrivelse af strandlinjer i Østerdalen, men angav desforuden ogsaa lignende fra Sel, Vaage og Lesje[24]). Hansen hævdede den glaciallakustrine theori ved «sammenhængende bræmasser, der skyder bræer op gjennem alle dalene»[25]). At hævde en saadan forskjel, som Hansen[26]) synes at ville gjøre, mellem denne theori og den af Agassiz opstillede er neppe gjørlig; thi man kan ved talrige exempler fra Grønland, Himalaya og Alperne paavise en række af overgangsformer — at man har is som opdæmmende faktor er i dette tilfælde det afgjørende; den kvantitative forskjel er af mindre væsentlig betydning, og det vil her være tilstrækkelig i saa henseende at gjøre opmærksom paa de instruktive exempler fra Martellthal[27]) og Alaska[28]) ligesom ogsaa de norske forekomster[29]).

Der udspandt sig nu efterhaanden en diskussion mellem Blytt, Hansen og Reusch angaaende Østerdalens og Gudbrandsdalens seteforekomster, en diskussion, som for en stor del førtes i «den Naturhistoriske forening» (Kristiania). I et møde 25 januar 1886 holdt Reusch her et foredrag om Gudbrandsdalens seter[30]). Naar der imidlertid i referatet af den paafølgende diskussion her siges, at Blytt erklærede sig enig i Hansens theori[31]), saa maa dette bero paa en misforstaaelse fra referentens side; thi Blytt har mundtlig meddelt mig, at han aldrig har været enig i Hansens theori. En anden ting er, at Blytt saavel ifølge den allerede ovenfor meddelte udtalelse angaaende Tønsætlinjen som ogsaa ifølge senere udtalelser[32]) indrømmer lokale bræsøer med lokale strandlinjeforekomster. Straks efter offentliggjorde saa Reusch en ganske kort opsats: «Vieflotten i Gudbrandsdalen»[33]). Senere har Hansen paa flere steder[34]) omtalt disse strandlinjeforekomster. Efter Hansen skal de være undersøgt og nivelleret af Rudolph[35]); men det har ikke været mig muligt at faa rede paa, om resultatet af disse undersøgelser endnu er offentliggjort.

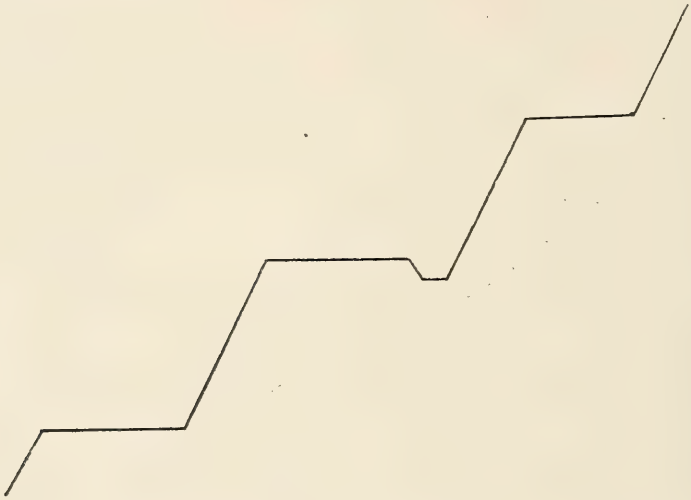
Seterne ialmindelighed betragter Blytt som strandmoræner[36]). Det var denne forklaring, Melvin[37]) og senere Reusch[38]) ogsaa søgte at gjøre gjældende. Jeg har ved en tidligere anledning[39]) givet den samme forklaring for dannelsen af de seter, man i Gudbrandsdalen træffer syd for det bekjendte pas Rosten — vel at mærke: i sin almindelighed; jeg angav enkelte undtagelser som lokale forekomster og gjorde desuden specielt opmærksom paa de lavere trin, der paa sine steder træffes nede i dalbunden. At forklare terrassedannelser som strandmoræner er imidlertid ingen ny theori — det er ikke en theori, som skyldes nogen af det sidste decenniums forskere; man maa gaa over femti aar tilbage i tiden. Bowmann offentliggjorde i aaret 1841 en afhandling: «On the Natural Terraces on the Eildon Hills being formed by the Action of Ancient Glaciers»[40]), af hvilken jeg skal hidsætte følgende: «As the fact of the former existence of glaciers in Scotland is now exciting general attention, and will soon, I doubt not, be firmly established, I might have silently left it to others to consider them at the true cause of these terraces, had not a recent visit from Prof. Agassiz afforded me an oppurtunity of giving him the details of my own observations, and of hearing from himself that the appearances I described have often been seen by him on the sides of existing glaciers — — — I feel persuaded that the theory of their formation by water must be abandoned, and that they must be considered to be the true morains of ancient glaciers»[41]). Man ser altsaa, at den store bræforskers navn staar i en noksaa nær indirekte forbindelse ogsaa med denne theoris oprindelse.

Efter den historiske oversigt over kjendskabet til Gudbrandsdalens seteforekomster skal jeg saa gaa over til at betragte disse noget mere detaljeret. Som allerede ovenfor nævnt har jeg ved en tidligere anledning omtalt seteforekomster syd for Rosten og skal derfor nu forbigaa disse. I forbigaaende skal dog opmærksomheden henledes paa det skille, som dette pas danner mellem to omraader, inden hvilke de løse afleiringer optræder paa en meget forskjelligartet maade. Nu maa man naturligvis ikke forbise, at forholdsvis nyere denudation, elveudgravning og jordskred f. ex., paa sine steder kan have øvet en betydelig indflydelse; men dette vil dog altid kun være rent lokalt — det kunde i denne forbindelse være tilstrækkelig at minde om den store flom, der i aaret 1789 anrettede saa store ødelæggelser i Østerdalen[42]), Gudbrandsdalen[43]) og Valders[44]). Ved Øvrebø (sydvest for Laurgaard, Rosten) hæver sig over de for sin Cicuta virosa bekjendte, flade og myrlændte strækninger endel grushauge med tildels afrundede stene, blandet med sand og ler; moræнegruset synes altsaa paa dette sted sikkert. Den tildels bastionagtige forekomst kunde imidlertid ogsaa henlede tanken paa terrassedannelse. Det lykkedes mig ikke at finde noget snit i disse grusmasser; men en mand paa Øvrebø fortalte mig, at under den brugte jord er her det grove grus almindelig udbredt, og naar man ved dybgravninger gaar længere ned, finder man i forskjellig dybde nede i gruset igjen et lag brugt jord. Netop her skulde imidlertid et større jordskred have fundet sted ved flommen i forrige aarhundrede, og som man ser, stemmer dette meget godt med lagfølgen i de løse afleiringer og med deres topografiske udseende.

Fra enden af Vaagevandet optræder østover store grus-afleiringer, denuderet og omleiret bundmoræne. Denne fortsætter ogsaa paa overgangen fra Vaage hoveddal forbi Selsvand, hvor der findes svære urer, til Sel. Det moutonnerede fjeld er paa dette strøg mindre tydelig udviklet paa grund af bergartens beskaffenhed, men dog tydelig nok til at angive fortsættelsen af den fra Vaage kjendte, østliggaaende hovedlinje. I Sel har Gudbrandsdalens hoveddalføre et sækkedallignende udseende, idet med Rosten en tilsyneladende sperring finder sted. Strandmoræneforekomst og utydelig skuring i selve Rostensnevringen viser imidlertid, at den ikke er af postglacial alder i sin helhed. Derimod er det nuværende, temmelig dybe elvegjel sikkerlig af postglacial alder; thi i dette saaes ingen isskuring. Om paa dette sted jettegrydedannelsen, som Gumælius[45]) antog, har spillet nogen fremtrædende rolle, kunde jeg ikke forvisse mig om — det er ikke usandsynlig, men heller ikke nødvendig. Man har nemlig i Søndre Fron ved Harpefossen et dybt gjel i dalbunden; dette gjel mangler ligesom Rostens isskuring — det er altsaa ligeledes postglacialt. Ved dette kan man imidlertid se, at jettegryder har øvet betydelig indflydelse ved dannelsen, og ved selve Harpefossen har man en hel del tildels store jettegryder, der har tiltrukket sig opmærksomhed allerede i forrige aarhundrede[46]). Paa den anden side har jeg ved Langglupelven (Ronderne) havt anledning til at undersøge et ligeledes postglacialt gjel, hvor ikke jettegryder, men bergartens strukturforhold viste sig af stor betydning. Det er derfor sandsynlig, at de eiendommelige strukturforhold med de talrige lithoklaser i Rostens konglomerat for en stor del har lettet elvens gjennembrydende arbeide.

Umiddelbart nord for Rostensnevringen optræder saa med engang svære grusmasser i bastionagtige terrasser. De er især udviklet i flere mere eller mindre adskilte trin paa dalens vestside. I et grustag paa den vestre side af veien saaes her etsteds et snit, der viste en udpræget lagning i grusmassen med svagt mod nord faldende lag. Lagene har høist forskjellig tykkelse, fra centimetertykkelse til et par decimeter. Bestanddelene er snart sand, snart ganske fin og snart blandet med indtil ertestore stene; snart haves lag med indtil centimeterstore stene, og snart forekommer ogsaa lag med noget større, afrundede stene, hvor det imidlertid ikke lykkedes mig at paavise nogen isskuring. Derefter sees en tilsyneladende horizontal, men ganske kort terrasse ved Rusten paa elvens østside; den tyve-tredive meter over elven liggende terrasse danner grundlaget for gaardens dyrkede mark og ligger noget lavere end den næste paa Laugens vestside optrædende terrasse, der synes sammenhængende og derfor i niveau med den kupperede morænemasse ved Brændhaugen. Herfra finder man saa videre mod nord dalbunden opfyldt af betydelige morænemasser, tildels terrasseformig udviklet: først en terrasse paa vestsiden, saa en noget høiere paa østsiden og derpaa igjen paa Laugens vestside et endnu noget høiere terrassetrin, der strækker sig helt frem til Ilken[47]). De her beskrevne grusafleiringer er tildels meget uregelmæssige i overfladen — det er den kupperede bundmoræne, det denuderede terrasseterræn, og grustag blotter paa flere steder en utydelig lagning. De maa holdes skarpt ud fra de høitliggende.

Ved Ilken optræder nu som fremspringende bastioner ved Jondalens udmunding i hoveddalen terrasser tilhorende de paa Dovre og Lesje optrædende strandlinjer. Man kan imidlertid her adskille flere trin, mindst tre. Paa strækningen fra Ilken mod nord til Toftebergene er linjerne tildels utydelige, paa sine steder derimod meget skarpe; hvad der her kunde iagttages, lader sig sammenstille i følgende skematiserede profil:



Selve strandlinjefladen kan paa sine steder omtrent forsvinde, paa andre udvide sig til over hundrede meter. Der er enkeltvis iagttaget et meterhøit opspring paa strandlinjefladens yderkant. Paa sine steder har man ved at følge midtlinjen anledning til at iagttage saavel et høiere som et lavere trin, hvert med en afvigelse af indtil efter øiemaal seks meters niveauforskjel fra midtlinjen. Det er mulig, at en noiagtigere undersøgelse kunde fremfinde endnu flere trin. Terrassernes materiale er, forsaavidt det kommer tilsyne, sand og grus, dertil større og mindre stene, som fordetmeste er afrundede, delvis ogsaa skarpkantede. Nede i dalbunden ser man ogsaa paa dette strøg denne jevnt fyldt af moræne- og terrassedannelser, disse sidste for en stor del af recent oprindelse.

Fra Toftemoen følger nu mod nord et ganske lavt terrassetrin paa Laugens vestside, saa paa østsiden et høiere trin, der længere nord har sin ekvivalent over igjen paa vestsiden — det er selve hovedlinjen, veien nu stiger op paa, idet man nærmer sig Domaas.

Fra toppen af den høide, der tæt ved Domaas hæver sig 35 meter over den meteorologiske station, har man en god udsigt over terrasserne paa Laugens sydvestlige side. I en høide af ca. 685 meter over havet befinder man sig her noget høiere end hovedlinjen, hvilket bidrager sit til, at fænomenet bedre kan overskues. Er end strandlinjen paa sine steder afbrudt, saa kan den dog meget let følges, tilsyneladende i samme horizontalniveau. Særlig skarpt fremtræder den i bastioner ved de i hoveddalen udmundende sideelve, f. ex. Djupdalsaaen. I detaljerne ser man imidlertid, at strandlinjefladen er meget ujevn tildels, og særlig bør opmærksomheden fæstes ved, at fladen ofte skraaner betydelig af udover mod den ydre kant. Et par bitrin, et lavere og et høiere end hovedlinjen, synes ogsaa her tildels at forekomme, om end ikke skarpt udviklet. Paa den nordøstlige side fremtræder i strandlinjehøiden den udprægede gaardrække.

Ved Hinaaen (nordvest for Domaas) fandtes ved dens nedre løb en tildels temmelig mægtig afleiring af fin, sandblandet ler, der viste sig tydelig laget. Paa sine steder sees antydning til foldning. De forskjellige lag er som regel meget tynde og udhæver sig meget skarpt ved sin snart lysere, snart mørkere farve, der idethele er graa med et skjær i det brune eller blaa. Ganske enkeltvis finder man indesluttet afrundede stene indtil halvdecimeterstore. Hyppigere findes marleker, hvoraf en flerhed itusloges, uden at fossiler kunde opdages. I denne forbindelse kan det nævnes, at Kjerulf omtaler marleker fra Lesje, men ogsaa uden fossiler[48]).

Fra Domaas til Holaker synes morænegruset vandslidt, og ved Holaker har man oppe i dalsiden over veien en tydelig afsats, der i høide svarer omtrent til strandlinjeniveauet. Dette gjenfinder man saa nord for Lesje kirke noksaa udpræget i veiens nærhed. Videre mod vest følger nu tildels større masser af morænegrus, og det er her ioinefaldende, at medens de høiere op i dalsiden optrædende grusmasser viser en fuldstændig morænekarakter, saa er dalbundens fyldning vandslidt og tildels omlagret. Ved Laugens udløb af Lesjeskogsvandet findes moræuegrus i store masser, tildels terrasseformig udviklet.

I den sydlige dalside optræder paa Lesje den saakaldte «viflaat», en udpræget afsats i dalsidens relief. Det er dog ikke blot en linje, men som allerede af Naumann bemærket to. Helt fra dalsnevringen ved Bottem[49]), der ligger ved enden af det nu udtappede Lesjevand, mod vest til Loraelven kan man forfølge to tydelige trin; de er rigtignok paa sine steder afbrudt, men skimtes dog nogenlunde sammenhængende. Det er især paa det sidste stykke, fra ret over for Lesje kirke til Loraelven, at linjerne er meget afbrudt. Ved Lordalens udmunding i hoveddalen optræder derpaa bastionagtige terrasser i to tydelige trin. Foruden de to hovedtrin, som kan følges langs dalsiden, optræder paa sine steder ogsaa et par bitrin, muligens flere. Fra Loraelvens terrasser kan videre mod vest enkelte utydelige og uregelmæssige linjer i flere trin skimtes i dalsidens relief.

Langs Lesjeskogsvandet ser man ingen strandlinjer; men derimod antyder endel flade, tildels myrlændte strækninger, endel lave, uregelmæssige terrassedannelser og vandslidt grus i dalbunden langs vandet dettes tidligere, høiere vandstand.

Ved Raumas udløb af Lesjeskogsvandet optræder i den flade, fordetmeste overdækkede dalbund paa flere steder fast fjeld næsten ud til elven paa begge sider. Moræneguset synes tildels vandslidt og terrænet for en stor del myrlændt.

Naar man fra nordøstsiden af Jettafjeld følger disse strandlinjer op til Lesjeskogsvandet, faar man et umiddelbart indtryk af, at de maa være horizontale. Til dette resultat kom ogsaa Chambers: «when examined with a correct instrument from its own elevation on the opposite side, it is proved to be for a great way truly horizontal»[50]). Fra Domaas og Holaker har jeg selv havt anledning til at undersøge disse linjers horizontalitet. Den korte tid, som stod til min raadighed, gjorde rigtignok, at undersøgelsen ikke blev saa nøiagtig, som den burde; men den nivellerede theodolit viste dog, at deres afvigelse fra den horizontale linje i ethvert fald maa være meget liden, om der overhovedet er nogen. Den af Reusch[51]) og Hansen[52]) førte diskussion om disse linjers heldningsforhold maa betragtes som frugtesløs, saalænge den kun er knyttet til et veinivellement, et foreløbigt jernbanenivellement og maalinger med aneroidbarometer; er saa dertil ikke i tilbørlig grad taget hensyn til linjernes ujevne karaktér og til den omstændighed, at der foruden de to hovedtrin ogsaa optræder bitrin, saa er derved saa mange muligheder aabnet, at enhver forsker af maalingerne næsten kan faa udbragt det for en opstillet theori nødvendige.

At man her har strandlinjer for sig, turde efter det foregaaende være indlysende nok. Der bliver ikke spørgsmaal om rækker nedgledne fra fjeldsiderne, og der bliver ikke spørgsmaal om gjenstaaende rester af en dalfyldning. Strandmorænetheorien finder i dette tilfælde ingen anvendelse — jeg har havt anledning til at se mange strandmoræner, saavel under dannelsen ved nu existerende bræer som fuldt udviklede efterladt af tidligere, men ingensteds saa jeg en strandmoræne med et profil som det fra linjen mellem Ilken og Toftebergene skematiserede. Forekomsten af den fine, sandblandede, i tydelige lag optrædende ler taler for afsætning i stillestaaende vand.

En nøiagtig nivellering af disse linjer vilde derfor være meget interessant, da den vilde kunne konstatere visse eiendommeligheder i jordskorpens bevægelse paa dette sted.

At man har at gjøre med en lakustrin dannelse og ikke en marin, tør ligeledes efter det foregaaende ansees godtgjort. Vigtigere er imidlertid spørgsmaalet om denne lakustrine dannelses udstrækning og om aarsagen til en lakustrin forekomst paa et sted, hvor det opdæmmende materiale er saa sporløst forsvundet som her.

Efter det foregaaende optræder strandlinjerne først et stykke nord for Rostensnevringen. Denne selv er glacial, og der findes ikke spor efter betydeligere løse afleiringer, som senere kunde være borteroderet af rindende vand — det eneste mulige som sperring paa dette sted er is. Paa denne maade vilde man her faa en indsø, der, saalænge den sperrende bræ rak til, vilde søge sit afløb over vandskillet mod nordvest, men tømmes forholdvis hurtig, naar forandringer i de klimatiske forhold medførte bræens tilbagegang. Om denne bræ var af mere lokal art, eller om det muligens var en udløber mod sydvest af den store bræerest, der længere mod nordøst i længere tid holdt sig østenfor vandskillet — alt dette maa en fremtidig detaljundersøgelse afgjøre. I en afhandling «Bidrag til Jotunfjeldenes glacialgeologi» har jeg søgt at vise, at det er omtrent paa dette sted, man maa søge det sydvestlige fremspring af den ovennævnte brærest. Paa bredderne af denne bræsø kunde man muligens ogsaa blandt andre istidsformer have seet mammuthen[53]) spadsere omkring.

Trykt den 23de September 1896.

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49. „Denne Gaard har uden Tvivl i fordum Dage hedt Bottenheim, og faaet Navn deraf, at den ligger ved Enden eller ved Botten af den lange Søe, som er omtrent en Miil lang, strækkende sig lige herfra til Lessje Kirke.“ (Budstikken (1820—21), B. 2, Pag. 595—596).

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MÆRKER EFTER ISTIDEN

I DET NORDLIGE AF GUDBRANDSDALEN

MED 1 KARTSKISSE

2 FOTOGRAFIER OG 3 PROFILER

AF

J. REKSTAD

KRISTIANIA

ALB. CAMMERMEYERS FORLAG

LARS SWANSTRØM

Kristiania — Centraltrykkeriet 1896.

Mærker efter istiden i det nordlige af Gudbrandsdalen.

Med 1 kartskisse, 2 fotografier og 3 profiler.

Af

J. Rekstad.

I sommeren 95 foretog jeg med understøttelse af Rathkes legat en reise i det nordlige af Gudbrandsdalen for at fortsætte undersøgelsen af mærkerne fra istiden. Da jeg i dette tidsskrifts 17de bind har givet en fremstilling[1]) af iagttagelser fra min første reise i Gudbrandsdalen i samme øiemed, vil jeg herved i tilslutning dertil give en beretning om denne.

Først skal jeg søge at paavise, hvorfra materialet i den fremtrædende moræneVold[2]), som ligger ved pladsen Sandbovangen kort nordenfor Sandbo paa grænsen mellem Kvam og Sel, er kommen. Dens bygning viser, at den er afsat af en overflademoræne. Den danner en omtrent 900 m. lang vold, der er saa noget nær lodret paa dalens længderetning og med temmelig brat forside, og den bestaar omtrent udelukkende af kantede stene af en lys kvartsskifer. Denne bergart er saa rent dominerende, at det er en sjeldenhed at se en sten af andet slags.

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[1]) Bræbevægelsen i Gudbrandsdalen mod slutningen af istiden.

[2]) Beskreven ibid.

Trykt den 23de September 1896.

Lad os, inden vi gaar videre, se lidt paa overflademorænernes beskaffenhed. De er, som navnet udsiger, moræner, der føres af bræerne paa isens overflade. Stenene i dem er kantede, medens de er afrundede og ofte med skuringsstriber i de moræner, som føres under isen. Overflademoræner deles i side- og midtmoræner. De første af disse dannes hovedsagelig af grus og stene, der fra bratte fjeldsider langs bræerne styrter ned paa isen. Her spredes dette materiale, eftersom bræen glider nedover, og kommer saaledes til at danne en vold eller banke, der dækker en mere eller mindre bred stribe af bræen langs bredden, en sidemoræne. Naar to bræer flyder sammen, forener de sammenstødende sidemoræner sig til en midtmoræne, saa kaldt, fordi den ligger langs den midtre del af den bræ, som fremstaar ved foreningen.

Fra Sels kirke og nordover til Laurgaard er der langs dalens østside saa bratte fjeldsider, at den fra disse nedramlede ur gaar helt ned til kongeveien, og bergarten her er ganske lig den, vi har i moræneu ved Sandbovangen. Den samme lyse kvartsskifer har vi i de bratte bergvægge langs den nordøstre side af veien over Vaagerusten fra Ulsvold og op til Rustepladsen. Her ligger en række endemoræner, som viser, at ismasserne, da disse moræner afsattes, fyldte Ottadalen i den grad, at en bræ pressedes over Vaagerusten og ned i Laagendalen. Hvorledes denne bræ skridt for skridt har trukket sig tilbage, eftersom isens mægtighed aftog, afgiver disse moræner vidnesbyrd om.

Den første af de nævnte endemoræner har vi ved gaarden Hougen, hvor passet eller sidedalen munder ud i Laagendalen. Den bestaar hovedsagelig af lerblandet grus og runde stene. Omtrent 1,5 km. længere op ved Grote ligger den næste, en mægtig stenvold, opstablet af store kantede blokke. 1 km. høiere op støder vi paa den følgende lige foran Selsvandet. Denne bestaar igjen af lerblandet grus og runde stene. Ved Bolstad ovenfor Selsvandet er der atter en endemoræn, væsentlig bestaaende af store kantede blokke, og herfra ligger der langs veien opover til Rustepladsen moræneliaug ved morænehaug. Endelig kommer den sidste endemoræne oppe i det høieste af skaret, 613 m. o. h. Dens form viser utvetydig, at den er afsat af en bræ, som er kommen fra vest, thi den er smukt krummet og vender med sin konkave side i den retning.

De bratte fjeldvægge i Sel med sine vældige urer af kvartsskifer har kunnet skaffe ned paa bræen materiale nok til den store moræne ved Sandbovangen. Bergarten er der fuldstændig lig morænens, og isen har bevæget sig i sydøstlig retning nedover dalen, saa alt taler for, at morænen skal stamme derfra. Afstanden mellem morænevolden og Sels kirke er omtrent 9 km. og til nordenden af Selsvandet 24 km., saa den veilængde, morænen er ført, i det væsentlige ligger inden disse grænser.

Morænevolden har, som ovenfor anført, en længde af omkring 900 m., og dens udstrækning lodret paa bræens længdeakse er ca. 600 m. Heraf kan vi slutte, at den ikke er dannet udelukkende af en sidemoræne, thi det er ikke tænkeligt, at en saadan skulde have havt en slig bredde her i en forholdsvis trang dal. Omtrent 6 km. ovenfor morænen stødte nu ogsaa Ottadalens ismasser til, hvilket maatte bevirke, at bræen fra Laagendalen indsnevredes, og følgelig maatte ogsaa dens sidemoræne blive smalere. Forøvrigt har man et afgjørende bevis for, at en midtmoræne har været medvirkende til frembringelsen af morænevolden, i det stenstrøede felt[1])

[1]) Nærmere beskrevet ibid.

(fot. 1), som strækker sig 600 m. nordover fra moræenen og 30 m. indenfor østre strandmoræne.

Dette stendække er utvivlsomt resterne af en midtmoræne, som blev liggende tilbage, da bræen smeltede bort.

Da moræenen er uden afbrydelse, ser vi deraf, at side- og midtmoræenen har bredt sig til et sammenhængende grusdække paa bræen, noget som ogsaa finder sted ved flere af nutidens isbræer[1]), naar der er rig tilgang paa materiale.

Sidemoræenen maa, efter hvad vi har set, stamme fra fjeldsiderne langs dalens østside mellem Sels kirke og Laurgaard, medens midtmoræenen antagelig er fremkommen, ved at isstrømmen over Vaagerusten har forenet sig med hoveddalens, og de bratte fjeldvægge langs østsiden af Selsvandet har da skaffet materiale til den.

Lad os nu se lidt paa, hvorledes det forholdt sig med bræerne her, da moræenen ved Sandbovangen afsattes. Isstrømmen i Ottadalen var saa mægtig, at den sendte en arm over Vaagerusten ned til hoveddalen. Her forenede denne sig med Laagendalens bræ, og den derved sammensatte isstrøm sluttede sig atter til Ottadalens igjen der, hvor dalene støder sammen.

Da resterne af midtmoræenen ved Sandbovangen ligger temmelig høit oppe i den østre dalside, kan man deraf slutte, at isbræen fra Laagendalen har været ubetydelig, sammenlignet med de ismasser, som kom fra Ottadalen og over Vaagerusten. Høideforholdene gjør det klart, at broen over Vaagerusten kun har været en arm fra hovedstrømmen i Ottadalen, thi det høieste af veien gjennem passet over Vaagerusten ligger 613 m. o. h., medens Vaagevandet ligger 351 m., og følgelig maa mægtigheden hos Ottadalens

[1]) Conf. Heim, Gletscherkunde pag. 347.

bræ have været mindst 262 m. større end hos armen over Vaagerusten.

For at faa et begreb om heldningen hos disse bræer vil vi anstille en liden beregning. Dalbunden ved Sandbovangen ligger 280 m. o. h. og det høieste af passet ved Vaagerusten 614 m. Afstanden mellem disse steder maalt paa amtskortet (horizontalprojektionen) er 26 km. Heraf følger det gjennemsnitlige fald af bræens underlag paa denne strækning 44′. Udføres en lignende beregning for Otta- og Laagendalen, finder vi, at faldet der blir mindre end 10′. Selv om vi antager, at isen over det høieste af Vaagerusten har havt en 300 m. større mægtighed end nede ved Sandbovangen, saa bliver alligevel ikke det gjennemsnitlige fald af isens overflade mere end 1° 23′. Dette er nok til at vise, at bræernes heldning paa denne strækning har under dette afsnit af istiden været omkring 1°. Tidligere, da isens mægtighed var større, maatte heldningen have været endda mindre.

Beliggenheden af den betydelige endemoræne ved Kolloen i Kvam[1]) fortæller os, at den er afsat af en bræ fra Hedalen. Om nu denne bræ har endt ved Kolloen samtidig med, at Ottadalens bræ stansede ved Sandbo i Kvam, kan ikke med sikkerhed afgjøres, men meget taler for, at saa er tilfældet. Isaafald har Hedalsbræen gaaet omtrent 5 km. længere ned i Gudbrandsdalen end Ottadalens.

Nordover fra Sandbo støder man ikke paa nogen endemoræne i hoveddalen, før man kommer til Laurgaard i Sel. Der har man paa vestsiden af Laagen en liden endemoræne, hvis beliggenhed viser, at den skyldes en bræ nordenfra

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[1]) Bræbevægelsen i Gudbrandsdalen mod slutningen af istiden. Archiv for Math. og Naturv. XVII.

Laagendalen. Dette bekræftes end yderligere ved de mange store blokke, som ligger paa moræuen kort nordenfor husene paa Laurgaard, af den konglomeratartede kvartsit, der staar kort ovenfor paa begge sider af Laagen.

Paa østsiden lidt søndenfor broen over Laagen ligger der tæt ved veien to betydelige moræneliauge, der bestaar af store kantede blokke med en del grus indimellem.

Den første endemoræne i Ottadalen begynder ved Dale og strækker sig herfra opover mod Aasoren i længden omkring 4,5 km. Partiet ned mod Dale paa østsiden af elven er ovenpaa temmelig fladt og bedækket med vældige kantede blokke. Ned mod Otta staar der en steil grusvæg ca. 30 m. høi. Paa vestsiden stiger moræneu terasssevis temmelig høit; nede ved elven bestaar den i overfladen af grus med lidt ler og enkelte runde blokke, men eftersom man stiger, bliver blokke mere og mere overveiende. Af bergarter saaes i denne moræne gl. skifer, kvartsit gneis og gabbro.

Da der nu mellem morænen ved Sandbovangen og disse endemoræner ikke findes noget trin som mærke efter bræernes stilstand, maa vi antage, at bræen i Laagendalen har trukket sig tilbage til Laurgaard og Hougen, omtrent 22 km., samtidig med, at bræen i Ottadalen kun har gaaet 8 km. tilbage til morænen ved Dalen.

Den følgende moræne i Ottadalen begynder lidt nordenfor Veggeim og strækker sig nordover til Eierfos. Der er omtrent 3,5 km. mellem denne og det øverste parti af den forangaaende moræne. Dens nedre del paa østsiden af elven er besaaet med kantede blokke, ofte store som huse. Længere op gaar den over til vestsiden og ved Eide atter over til østsiden igjen; elven slynger sig altsaa frem igjennem morænen snart paa den ene og snart paa den anden side. Mellem Eide og Eierfos viser morænegruset flere steder lagning, hvilket rimeligvis hidrører fra, at elven har flydt ud over større partier af moræneu, førend den fik skaaret sit nuværende leie.

Nedover lien, hvor veien til Hedalen gaar op fra Lalumsbro, ligger der en mængde grus og blokke, og oppe i skaret støder man paa betydelige moræner paa begge sider af veien. En bræ har altsaa skudt sig frem igjennem dette skar og ned i Ottadalen. Ismasserne maa da have fyldt Hedalen, saa den ikke kunde skaffe afløb nok; en del af overfloden er bleven presset over her til Ottadalen. Da isdækkets mægtighed blev mindre, trak denne bræ sig tilbage og stansede en tid fremme i skaret, hvor den har afsat en ret betydelig endemoræne.

Blokkene her bestaar hovedsagelig af gabbro, gl. skifer og kvartsit.

Langs den nordøstre side af Ottadalen staar en bergryg frem, som begynder ved Øye lidt nordenfor det sted, hvor veien over Rusten tager op, og strækker sig op imod Sørum. Ved den sydøstlige ende af denne bergryg ligger der en betydelig moræne, der hovedsagelig bestaar af kantede og runde blokke. Moræuen viser os, at den sydøstre ende af ryggen danner læsiden, og at altsaa bevægelsen har gaaet i sydøstlig retning.

Omtrent mellem Skedsvold og Svare i Vaage ligger der langs den øvre side af den vei, som fører forbi Haakenstad op til sæteren og videre over fjeldet til Lesja, en række morænerygge, paa det nærmeste parallele med Finnas leie; en af de smukkest udviklede har retningen S 76° O retv. Hovedmassen i dem er grus og runde stene, men hist og her ligger der store kantede blokke. De bergarter, der saaes i blokkene, var gneis, kvartsit, gl. skifer og gabbro. Af kvartsitblokkene kan man se, at isens bevægelse her har gaaet i nordlig retning, thi denne bergart staar kort søndenfor moræneryggene, medens den ikke forekommer længere nord.

Vender vi os til hoveddalen igjen, saa støder vi her paa en tydelig sidemoræne i den østre dalside lidt nordenfor Laurgaard, ca. 450 m. o. h. Længere nord, omtrent ved grænsen mellem Sel og Dovre, begynder der langs dalens vestre side en terrasseformig moræne, som strækker sig op til Brændhaugen. Ned mod Laagen er den i stor udstrækning dækket af laget grus, men høiere op gaar den over til typisk moræne, bestaaende af ler, blandet med grus og store blokke. Paa sydsiden af Ilka, omtrent fra Storeng til Stampeli, ligger der igjen en terrasseformig moræne, fuldstændig lig den søndenfor Brændhaugen.

Høiere oppe ved Ilka træffer man de første af de smukt udviklede terrasser, som er saa fremtrædende opigjennem Dovre og Lesja. Ovenfor disse i det nederste af Jetdalen er der betydelige moræner, hvilket viser, at en bræ er kommen frem her fra vest til Laagendalen.

Igjennem en stor del af Lesja er den nordøstre dalside dækket af tildels mægtig moræne. En mængde blokke, ikke sjelden store som huse, ligger udover jorderne, og det uagtet mange maa være blevne sprængte istykker og skaffede bort af beboerne i tidens løb. Særligt fremtrædende er dette morænedække ved Norstebo, fra Holaker til Hattrem og op for Løftingsmo.

I den nedre del af Lordalen er der betydelige endemoræner og foran disse mægtige grusterrasser. En stor isbræ maa altsaa være kommen efter denne sidedal, som fra Lesja gaar i sydvestlig retning omtrent 30 km. ind til den 1926 m. høie Skarvdalsegg.

Det betydeligste moræenefelt heroppe har vi ved vandskillet. Det begynder ikke langt fra skydsstationen Holsæt og strækker sig efter dalføret til gaarden Bryggen ved Lesjeskogens vand, saa den samlede længde bliver omtrent 16 km. Paa denne strækning ligger der moræenehaug ved moræenehaug, og vi maa følgelig slutte, at iskanten har holdt sig længe her. Mest typisk er moræenepartiet ved Lesjeværk udviklet. Her bestaar moræenehaugene af grus og runde stene, sjelden større end et mandsløft, og flere af disse hauge rager omkring 20 m. op over de omliggende dele af moræenen. Lesjeskogens vand er opfyldt af holmer, og disse er alle uden undtagelse, saavidt jeg kunde se, moræenehauge. Paa flere steder i dette moræenelandskab er der flade furumoer, hvor gruset ofte viser lagning og med enkelte større blokke inde i den lagede masse. Flerheden af dem ligger omkring 630 m. o. h.

Flytblokke.

De fremmede blokke, som findes spredte om, giver i forbindelse med skuringsstriberne den sikreste veiledning til bestemmelse af ismassernes bevægelsesretning. Nedenfor vil jeg anføre en del iagttagelser af fremmede blokke fra denne trakt.

Opefter Laagendalen fra Brændhaugen til Dombaas ligger der blokke af Rustens konglomeratartede kvartsit, altsaa et utvetydigt vidnesbyrd om, at bevægelsen her har gaaet opefter dalen.

Blokke af lys granit er heller ikke sjeldne i denne del af dalen. Om de stammer fra granitgangene i Jettafjeld[1]) eller fra Dovres granit, er ikke let at afgjøre med sikkerhed.

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[1]) Confr. Kjeruf, Det sydlige Norges geologi pag. 25.

Isens bevægelsesretning taler til gunst for den første antagelse. Imidlertid kan det nok tænkes, at blokke er bleven førte sydover af drivis i den store sjø, som har været opdæmmet i Dovre og Lesja under sidste afsnit af istiden. Til støtte for den antagelse, at granitblokkene skulde være komne nordenfra, kan ogsaa anføres, at de optræder adskillig talrigere ved Dombaas end længere syd i dalen. Her er bergarten gl. skifer, men graniten staar kort nordenfor.

Blokke af blaagraa stribet kvartsit saaes flere steder i Laagendalen nordenfor denne bergarts nordgrænse i fast fjeld, saasom i Dovre mellem Brændhaugen og Talleraas bro samt ved Trondhjemsveien ovenfor Dombaas og i Lesja ved Løftingsmo, Holsæt og Rise. Dette antyder en bevægelse i nordvestlig retning.

I Lesja optræder granitblokke af lysegraa farve, som Dovregraniten, vestover til Hattrem og ved Løftingsmo, Holsæt og Rise blokke af gl. skifer, hvilket igjen viser en bevægelse mod nordvest.

Gabbroblokke tildels stribede findes i betydelig mængde nedefter Ottadalen fra Vaagevandet, og fra Vaagerusten nedover til moræneme foran Selsvandet har man ligeledes blokke af denne bergart, undertiden af flere kubikmeters størrelse. I det nordlige af Laagendalen er de derimod ikke hyppige. Der forekommer gabbroblokke ved Brændhaugen og Dombaas i Dovre og ved Nørstebø, Holaker, Holsæt, Rise og Dosæt i Lesja, men paa alle disse steder kun i ringe antal.

Nedefter Ottadalen ligger der talrige gneisblokke, som maa stamme fra det store gneisfelt ved Vaagevandet; af mere usikker herkomst er de blokke af gneis og øiegneis, som optræder ved Dombaas.

Nedigjennem Hedalen er gabbroblokke meget hyppige. Ved Holen, Bjølstad og Heringstad forekommer ogsaa blokke af stribet granit, gneis, fyllitskifer, krystallinsk kalksten og dolomit. Bloktransporten her maa altsaa have gaaet i østlig og sydøstlig retning.

Blokke af dolomit iagttoges ogsaa i moræenen ved Kolloen og ved Ulsvold, ca. 2 km. vest for Laurgaard. Kalksten og dolomit optræder imidlertid paa flere steder i gl. skiferafdelingen her og da ogsaa i forbindelse med vegsten, saa disse bergarter er lidet skikkede som ledblokke.

Skuringsstriber.

Retningen er regnet fra den astronomiske meridian, idet kompassets misvisning er sat til 12° vestlig.

Dovre prestegjeld:

55	Ved hovedveien ca. 1 km. syd for Dombaas	N 1° O[1])
56	Ved det vestlige af berghammeren ved Dombaas	N 21° W
57	Omtrent 100 m. længere øst paa hammeren .	N 15° W
58	Ved Trondhjemsveien 2 1/2 km. ovenfor Dombaas	N 21° O
59	- — 3 1/2 - » —	N 35° O

Lesje prestegjeld:

60	Ved hovedveien 1/2 km. NW for Lesjeværk .	N 72° W
61	- — 7 - » - —	N 62° W

Vaage prestegjeld:

62	Ved Lykken lidt ovenfor Aasoren	S 79° O[2])
63	Omtrent 1 km. W for Lykken ved veien . .	S 102° O
64	2 km. NW for Snerle skydsstation ved veien	S 44° O
65	Nord for vestenden af Flatningen, 800 m. o. h.	N 3° O
66	Ved det nordlige af Bringsfjeld[3]), 850 m. o. h.	N 8° O

[1]) Stærk skuring paa skraa bergflader ved den østre side af veien.

[2]) Her er smukke stødsider mod NW.

[3]) Bringsfjeld er paa Amtskortet benævnt Ringsfjeld.

Trykt den 8de Oktober 1896.

Skuringsstribernes retning er for lettere oversigts skyld indtegnet paa vedføiede kartskisse.

Af skuringsstriberne, flytblokkene og moræenerne kan vi se, at isen har bevæget sig ud fra landets høieste fjeldparti, følgende terrænets indsænkninger. Naar ismasserne har været for betydelige til at kunne faa afløb nok igjennem dalene, er en del bleven presset over høidedragene. Heroppe har bevægelsen bedre kunnet følge den retning, hvori trykket virkede, medens nede i dalene terrænets ujevnheder har havt en stærk indflydelse paa bevægelsesretningen.

Skillet mellem bevægelsen opefter og nedefter Gudbrandsdalen maa have ligget omtrent ved grænsen mellem Sel og Dovre; thi som ovenfor anført findes blokke af Rustens konglomerat førte nordover til Dombaas og sydover til Laurgaard.

Terrasser.

Naar man kommer opefter Gudbrandsdalen, begynder der fra Talleraas bro over Laagen en række terrasserester opigjennem Dovre, særlig langs dalens østside; paa disse ligger flere af gaardene. De bestaar af ler, mere eller mindre opblandet med fin sand, og viser særdeles tydelig lagning, saa det er klart, de maa være udfældte i en sjø. Smukkest udviklede er de opefter Dovrebygden til opimod Dombaas, men man har ogsaa lag af det samme slags sandblandede ler vestover i Lesja til lidt bortenfor Holsæt. I høiden gaar det lagede ler paa sine steder op til 550 m. o. h. Jeg søgte paa flere steder i berglagene efter dyre- eller planterester, men uden noget resultat.

Omtrent paa samme strækning ligger der temmelig høit oppe i den vestre dalside en række terrasser, som sees særdeles godt fra landeveien, som her gaar paa østsiden.

De begynder op for Storeng i Dovre og kan følges med større eller mindre afbrydelser til Lora i Lesja, det vil sige paa en strækning af omtrent 40 km.

Høiden over havet af disse terrasser maaltes med aneroid, hvis skala kort iforveien var bleven korrigeret ved det meteorologiske institut. For yderligere korrektion af dets variation sammenholdtes det flere gange med stationsbarometret paa Dombaas.

Ved interpolation mellem de daglige observationer paa Dombaas fandtes barometerstand og temperatur der paa de tider, lufttryk og temperatur maaltes paa terrasserne med aneroid og slyngetermometer. Heraf beregnedes saa høideforskjellen mellem terrasserne og Dombaas[1]). Da observationerne udførtes under rolige veirforholde og ingen i større afstand end 25 km. fra Dombaas, saa undlod jeg at tage hensyn til lufttrykkets variation paa de forholdsvis korte distancer mellem Dombaas øg observationsstederne.

Vi skal nu se lidt nærmere paa de enkelte terrassestykker. De første har vi, som før nævnt, op for Storeng paa sydsiden af Ilka[2]). Det øverste trin her (684 m. o. h.) danner en næsten horizontal og temmelig bred flade, bestaaende af grovt grus med enkelte større runde stene. Vestenfor i Jetdalen og noget høiere har man moræner, og herfra har antagelig elven taget materialet til disse terrasser. Det sydvestlige af den øverste terrasse (tilv. paa fot. 2) danner et lavere trin (675 m. o. h.) med ryggen smukt indskaaret det høiereliggende parti af terrassen. Gruset er her ikke saa grovt og de store stene meget sjeldnere.

Høiden over havet af Dombaas station fik jeg opgivet til 648,9 m.

2) Se fot. 2.

Endelig ligger der længere nede en grusmasse, der har horizontal overflade og paa 3 kanter regelmæssig skraanende sider. Dens fjerde side støtter sig til dalsiden, saa den faar formen af en afskaaren pyramide med rundede hjørner. Dens top ligger 618 m. o. h.

Fra den østre dalside kan man se, hvorledes den øverste terrasse ved Storeng strækker sig nordover til midt for Toftemoen, kun afbrudt der, hvor Ilka har skaaret sig igjennem den. Den samlede længde af denne terrasse bliver da omkring 6,5 km. Overfor Dovre kirke kan man tydelig se to parallele terrasser, som ved maaling fandtes at ligge 672 m. og 652 m. o. h. Altsaa ligger det øverste trin her 12 m. lavere end ved Storeng, hvis man kan stole paa disse maalinger, der udførtes med to dages mellemrum. Heldigst vilde det være, om det kunde lade sig gjøre at faa udført et nivellement langs denne terrasserække igjennem Dovre og Lesja.

Det lavere trin har her form af en flad afsats, der bestaar af grovt grus med runde stene. Flere steder gaar det over til en bredere eller smalere grusryg med en fordybning mellem dalsiden og grusbanken. Det øvre trin ser ud som en typisk sidemoræne med en mængde store blokke i gruset.

Herfra seet viser der sig en horizontal linie i den østre dalside fra Angaard og nordover til Einbugaa. Op for Haugen fandtes dens høide 636 m., og her danner den en stærkt skraanende flade, bestaaende af morænegrus. Lige ved paa nordsiden har Dragaa skaaret sig ned igjennem mægtige masser af moræneler.

Ligeoverfor Nørstebø i Lesja er der atter to tydelige terrasser i 700 og 665 m. o. h. Den øverste er en typisk sidemoræne, og ovenfor staar fast berg frem i dagen. Den nedre danner her en bred flade, hvis indre parti er dækket af en mængde store blokke, medens dens forreste del hovedsagelig bestaar af grus.

Disse to terrasser ender i vest mod en berghammer, paa hvis anden side der igjen begynder en terrasse omtrent ligeoverfor Holaker. Den strækker sig vestover gjennem Bølien et godt stykke. Jeg gik 2,5 km. langs denne terrasse fra dens østre ende, idet jeg hyppig aflæste barometret. Det steg paa denne strækning i løbet af 1 time og 10 min. 0,6 mm. Paa samme tid steg stationsbarometret paa Dombaas i 6 timer 2,6 mm., hvilket giver i 1 time og 10 min. 0,5 mm. Heraf kan vi se, at terrassen paa disse 2,5 mm. er saavidt horizontal, saa der ikke med aneroid kunde paavises nogen heldning. Dens høide over havet er 674 m. Dens østlige del ser ud som en sidemoræne med flere store blokke; blandt disse kan nævnes en vældig kantet granitblok og en af gneis. Fig. 3 A viser et skematiseret tversnit af dette parti af terrassen. Længere mod vest bliver den bredere, dens forreste kant, der væsentlig bestaar af grovt grus, rager lidt op, og indenfor denne er der en myrstrimmel. Fig. 3 B giver et skematiseret tversnit af denne del. Det vestligste af den strækning, jeg tilbagelagde, har form af en grusryg, der enkelte steder breder sig ud og forgrener sig til to eller flere rygge. Fig. 3 C giver et skematiseret tversnit af dette parti.

Ved det nederste af Lora har man mægtige terrasseformige afleiringer af sand, der af elven er ført nedover fra de betydelige moræner, som ligger høiere oppe i Lordalen. Her er to udprægede terrassetrin, et ved 632 m. o. h. og det andet ved 658 m., men laget sand forekommer op til 700 m. o. h. Bortover Lesjeskogen fra Rise til Lesjeværk og langs Lesjeskogens vand er der flere steder grusflader med lagning i en høide af omkring 630 m. o. h.

For lettere oversigt er der udarbeidet en grafisk fremstilling af terrasserne (fig. 4), idet afstanden mellem de maalte terrasser er afsatte som abscisser og høiderne som ordinater. Disse sidste er tegnede i 100 gange større maalestok end de første, thi ellers vilde de optrukne linier kun umærkeligt have afveget fra horizontalen. Vi ser, at de maalte terrassehøider lader sig indordne i 3 trin; vistnok er ikke de optrukne linier horizontale, de viser tvertimod for de to øvres vedkommende et noget uregelmæssigt forløb, men dette kan vel for en del skrive sig fra feil ved maalingerne, som maaske i ugunstigste tilfælde naar op til 10 m.

De maalte terrassehøider.

	Øverste trin.	Mellemste trin.	Nederste trin.
	m.	m.	m.
Ved Jekla	684	675	618
Mod Dovre kirke .	672	652	—
- Nørstebø . .	700	665	—
- Holaker . . .	—	674	—
Ved Lora	700	658	632
Lesjeskogen . . .	—	—	630

Den største afvigelse mellem de maalte høider er i øverste trin 28 m., i det andet 23 m. og i det nederste trin 14 m. Ved den øverste terrasserække kan man ikke vente fuldstændig horizontalitet, thi dens moræneartede natur tyder paa, at den er dannet ved isens virksomhed. Hvorledes forholdet er ved de to nedre trin, kan kun et nivellement med fuld sikkerhed afgjøre. Naar dr. Andr. Hansen i sit interessante arbeide[1]) kommer til det resultat, at terrasserne

[1]) Strandliniestudier, Archiv for Math. og Naturv. XIV og XV.

sænker sig opefter dalen, saa fremkommer det for denne trakts vedkommende, ved at øverste trin syd i dalen sættes i forbindelse med trin, der tilhører et lavere niveau, længere nord, f. eks. øverste terrasse ved Storeng med den lavere ved Lora.

Det mægtige og udstrakte moræenefelt ved Lesjeskogens vand viser, at iskanten har holdt sig meget længe her. Bevægelsen hos de ismasser, som da fyldte det nordlige af Gudbrandsdalen, maatte være forholdsvis ringe, fordi dette isbassin intet afløb havde, og dets vigtigste tilløb var i nærheden af enderne, nemlig bræerne gjennem Jetdalen og Lordalen. Eftersom afsmeltningen skred frem, samlede der sig mere og mere vand under isen her, thi det sydlige af Gudbrandsdalen fyldtes endnu stadig af ismasserne fra Jotunfjeldene. Dette bevirkede, at friktionen mod underlaget blev mindre. Under saadanne forholde maatte isens overflade i bassinet nærme sig mere og mere til at blive horizontal.

Den øverste moræneartede terrasserække maa antages frembragt ved isens bevægelse langs dalsiderne. Til støtte for en saadan antagelse gjælder det at føre bevis for, at isen i et længere tidsrum har holdt sig i nogenlunde samme høide og havt paa det nærmeste horizontal overflade. De betydelige moræner ved Lesjeskogens vand afgiver et klart vidnesbyrd om, at isens mægtighed længe har holdt sig uforanderlig, og vi har netop seet, der kan anføres flere grunde for, at isens overflade her har været meget nær horizontal.

Allerede før den øvre terrasserække dannedes, havde bræen i Jetdalen trukket sig bagover til morænerne inde i dalen, og inden det andet trin afsattes, var ogsaa bræen i Lordalen gaaet tilbage til de før nævnte moræner bag terrasserne her. I Jetdalen ligger ogsaa øverste terrasse foran moræuerne, medens det øverste trin mangler i Lordalen, de tvende lavere findes der nedenfor moræuerne. Som ækvivalent til øverste trin optræder her sandlag i den nordvestlige dalside.

Den anden terrasserække har over store strækninger form af en bred grusflade, hvilket tyder paa, at den maa være en stranddannelse. Imidlertid viser dens moræneartede natur ved Holaker og flere steder, at ogsaa isen har været med i spillet. Ved tiden for dens dannelse maatte da afsmeltningen være saavidt fremskreden, at en stor sjø var fremstaaet her. Dennes overflade havde endnu et isdække, der trykkedes saa stærkt opover mod den nordvestlige ende af ismasserne syd i dalen, at den dæmmedes op 35 m. over vandskillet, der, som vi straks skal se, laa omtrent 14 m. høiere end nu. Middelhøiden af anden terrasserække er 665 m., medens nederste trin, der maa antages at svare til høiden af vandskillet ved slutningen af istiden, ligger 630 m. o. h. Lesjeskogens vand, det nuværende vandskil, ligger 616 m. o. h. eller 14 m. lavere end nederste trin, og saa meget maa da elvene have skaaret sig ned her siden istiden. Naar man ser grusvæggene paa begge sider af Laagen der, hvor den flyder ud af Lesjeskogens vand, finder man ikke noget urimeligt heri. Da isen smeltede bort i det sydlige af dalen, tømtes ikke denne sjø fuldstændig; der blev et betydeligt parti af den staaende igjen, særlig i Dovre, og dette tømtes først lidt efter lidt, eftersom Laagen mellem Laurgaard og Brændhaugen fik skaaret sin 5 km. lange bergrende gjennem Rusten dybere og dybere ned.

Som vi har seet, ligger de fleste af terrasserne i de to overste trin langs dalens sydvestre side. Dette kan ikke være tilfældigt, men maa hænge sammen med de forholde, hvorunder disse terrasser er fremstaaede. Da de dannedes, dækkede endnu ismasser det meste af landet paa vestsiden af Gudbrandsdalen, medens landet paa dens modsatte side var omtrent isfrit, følgelig maatte den større mængde vand og is fra vest skaffe mere materiale tilveie til dannelse af moræner og terrasser og saaledes fortrinsvis begunstige deres fremstaaen paa den side af dalen.

I Hedalen er der en særdeles fremtrædende terrasse langs dalens østside. Den begynder lidt søndenfor Ekre og strækker sig opover til Bjølstad i længden omkring 6,5 km. Jeg gik langs den i hele dens udstrækning, idet jeg ofte aflæste barometret. Det viste sig herved, at den stiger forholdsvis jevnt hele veien, saa den ved Bjølstad er 56 m. høiere end ved den sydlige ende. Fig. 5 viser heldningen 50 gange forstørret. Afstandene er afsatte som abscisser og de fundne høider som ordinater. Bjølstads høide over havet fandtes med aneroid at være 496 m, og herpaa er da den absolute høideangivelse paa fig. 5 baseret, hvorfor den vel ikke kan gjøre krav paa nogen stor nøiagtighed. Terrassens heldning eller høideforskjellen mellem de enkelte punkter langs den bestemtes derimod, ved at jeg i løbet af to timer langs efter den aflæste aneroiden, hvorfor feilene i de relative høider eller i heldningen ikke kan blive af nogen nævneværdig betydning.

Den sydlige del af terrassen opover til Steinflusbø bestaar hovedsagelig af grus og ler, og her har i tidens løb rindende vand skaaret den op i en række kegleformede hauge. Fra Ellingsbø nordover til Bjølstad er den mere sammenhængende, kun gjennemskaaren der, hvor bække kommer ned. Paa denne strækning optræder der ikke faa store blokke, undertiden paa flere kubikmeter. Ofte ligger de paa den forreste kant af terrassefladen og nedover den bratte forside. De fleste gaarde i denne del af Hedalen ligger langs terrassen, hvis overflade skraaner mere eller mindre stærkt ud mod dalbunden. Dens stærke heldning sydefter dalen og de store blokke paa partiet mellem Ellingsbø og Bjølstad taler tydeligt nok for, at det er en sidemoræne, vi her har i terrassedragt. Der er imidlertid flere mærker efter en sjø, der har dækket dalbunden her ved istidens afslutning. Denne tømtes, efterhvert som Sjoa skar sin rende ned igjennem bergsnevringen ved Skjervdalen. Hvor høit den kan have naaet, er ikke godt at sige, men den synes at have staaet over terrassen.

Oppe i Hedalens skogbygd ligger der grusterrasser paa begge sider af Sjoa i en høide af 648 m. o. h. Mellem disse er der en omtrens 80 m. dyb spalteformet rende, paa hvis bund Sjoa flyder. Alt taler for, at dalen ved slutningen af istiden her har været fyldt i høide med terrasserne af bergras. Siden den tid har Sjoa først skaaret sig ned igjennem et omtrent 60 m. mægtigt lag af morænegrus og derpaa udhulet sig en omtrent 20 m. dyb rende i det underliggende berg. En saa betydelig erosion tyder paa, at istiden ikke kan ligge os saa ganske nær.

Nedenfor er dalbunden helt ned til kirken dækket af grovt brægrus og større runde stene, som Sjoa har ført nedover ved udgravningen af sit leie oppe i skogbygden.

ON A NEW
FRESH-WATER OSTRACOD
STENOCYPRIS CHEVREUXI
G. O. SARS

WITH NOTES ON SOME OTHER
ENTOMOSTRACA RAISED FROM DRIED MUD
FROM ALGERIA

BY

G. O. SARS

WITH 2 AUTOGRAPHIC PLATES

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On a new Fresh-water Ostracod, **Stenocypris Chevreuxi.** G. O. Sars, with Notes on some other Entomostraca raised from Dried Mud from Algeria.

With 2 autographic plates.

By G. O. Sars.

Introduction.

On the 1st August last year, I received, through the kindness of the well-known French naturalist M. E. Chevreux, 2 tubes with dried mud taken by him from 2 different localities in the neighbourhood of Bona, Algeria. The one sample was taken on the 6th July of the same year from the swamp of »Bon Kamera«, the other on the 8th July, from that of »Kharezas«. Each sample was moreover accompanied by some spirit specimens taken from the same localities. Immediately after the receipt of the samples, I arranged a number of aquaria, each to receive small quantities of the mud, and I have been continuing my experiments not only during the remainder of the summer and autumn, but also during the whole winter until the present time, the aquaria having been placed in a room continually heated.

Trykt den 8de Oktober 1896.

By these means, I have been enabled to raise from the mud, and domesticate, a number of Entomostraca belonging to all of the 3 leading groups, Cladocera, Ostracoda and Copepoda. As might be expected, the greater number of the species have turned out to be identical with well-known European forms. But, as the localities do not in fact belong to the European continent, I think it may be of some interest to note the species briefly, and I shall do so at the close of this paper. Among the species raised was a rather beautiful Ostracod, which I cannot identify with any of the earlier known species, and which I therefore regard as new to science. The description of this form will be the chief object of the present paper, and I have much pleasure in dedicating the species to the distinguished French zoologist, to whom I am indebted for the mud from which it was raised.

Fam. Cyprididæ.

Gen. **Stenocypris**, G. O. Sars, 1889.

This genus was established by the present author in his paper »On some Australian fresh-water Ostracoda raised from dried mud«, and the species *S. Malcolmsonii* (Baird) was there described as the type of the genus. At the same time, attention was drawn to the fact, that the well-known European form, *Cypris fasciata*, Müll., ought to be referred to the same genus. With equal certainty another European species, *Cypris Fischeri*, Lilljeborg, may also be adduced to this genus, and as a 4th species, the Algerian form described below is now added.

Stenocypris Chevreuxi, G. O. Sars.

(Pl. 1 & 2).

Specific Characters.—♀ Shell, seen laterally, oblong reniform, height about equalling 2/5 of the length, anterior extremity somewhat obliquely rounded, posterior obtusely produced, dorsal margin perfectly straight in the middle, and subangular above the eye, ventral slightly sinuated in front of the middle:—seen from above, oblong fusiform, greatest width about equalling 1/3 of the length and occurring behind the middle, both extremities obtusely pointed. Valves very unequal, the left one being much the larger, and overlapping the right considerably both in front and behind; inner duplicatures of moderate size, and somewhat different in the 2 valves. Surface of shell smooth and polished, clothed at both extremities with hairs, those of the hind extremity remarkably elongated and less densely crowded than on the anterior. Natatory setæ of the inferior antennæ extending to the tips of the terminal claws. Caudal rami rather strong, though narrower than in the type species, and perfectly equal, outer half of the dorsal edge divided into 4—5 slight lobes, each armed with a comb-like series of teeth; terminal claw about twice as long as the other, both coarsely denticulated on their concave edge, apical seta rather elongated, that of the dorsal edge very small and occurring close to the proximal claw. Colour light greenish, clouded with darker shadows. Length of adult female 2.40 mm.

Remarks.—In its general appearance, this form shows some resemblance to the well-known European species, *Herpetocypris reptans* (Baird), exhibiting a similar elongated reniform shape of the shell. It cannot, however, even be referred to the same genus, as the natatory setæ of the inferior antennæ are fairly well developed, allowing the animal to move rather quickly through the water. In this, as also in other respects, it agrees with the species of the genus *Stenocypris,* though exhibiting well-marked specific differences from any of them.

Description of the female.

In fully adult specimens the shell has a length of 2.40 mm., a height of 1.00 mm., and a width of 0.80 mm. This form accordingly grows to a larger size than any of the other 4 as yet known species of the genus.

Seen from the side (Pl. 1, fig. 1), the shell exhibits a rather elongated, subreniform shape, the greatest height but little exceeding $^{2}/_{5}$ of the length. The dorsal margin is perfectly straight and horizontal, joining the anterior margin by an abrupt, nearly angular bend just above the eye. Posteriorly it passes by a more even curve into the hind margin. The inferior margin exhibits, somewhat in front of the middle, a rather slight sinus, and joins the anterior and posterior margins without any intervening angle. The anterior extremity is broadly rounded, and somewhat obliquely deflexed, whereas the posterior one appears more produced, and narrowly rounded at the tip.

Seen from above (fig. 2), the shell appears moderately compressed, exhibiting an oblong subfusiform shape, with the greatest width about equalling $^{1}/_{3}$ of the length and occurring behind the middle. The side-contours are but slightly curved, and both extremities appear obtusely pointed, the anterior one being a little narrower than the posterior.

The surface of the shell is quite smooth and polished, with only the usual small distant pits, and is densely clothed with hairs on both extremities, those of the anterior one being very delicate and densely crowded, whereas those of the posterior extremity appear much coarser and more distant, some being of very considerable length. In the centre of each valve, somewhat in front of the middle, the insertion for the adductor muscle of the shell is easily observable as a number of well-defined clear spots, the 2 anterior of which lie somewhat apart from the other 4 (see figs. 1, 4).

The valves are very unequal in size, the left one (see fig. 3) being much larger than the right (fig. 4), and overlapping it considerably both in front and behind, as also along the ventral face (see fig. 1). The form of the two valves also appear, when isolated (comp. figs. 3 and 4), rather dissimilar, the left one (fig. 3) having the anterior extremity rather more deflexed, and the posterior one somewhat broader than the right valve (fig. 4). The inner duplicatures are rather large, especially that of the anterior extremity. On the left valve (fig. 3) this anterior duplicature exhibits the usual semilunar, shelf-like form, and has a transversely striated peripheric area surmounted by a pellucid rim. On the right valve (fig. 4), this duplicature has a rather different appearance, forming inside a rounded expansion, and entirely without any transverse striation. The posterior duplicature is comparatively broader on the left valve (fig. 3) than on the right, and has the peripheric area striated in a similar manner to that of the anterior duplicature: the striation may also be traced along the whole ventral face of the valve. Just within the inferior sinus, both valves form a short lingular expansion extended straight inwards, that of the right valve being overlapped by that of the left, when the shell is closed. As in other Cypridids, the valves are connected along the dorsal face

Trykt den 8de Oktober 1896.

by a sort of hinge, having inside an elastic ligament which tends to keep the valves apart. By the aid, however, of a strong adductor muscle, traversing the body and joining each valve near its centre, the shell admits of being perfectly closed, in which case all the parts of the animal are enclosed within the cavity of the shell. Each valve is composed of an outer chitinous lamella of a rather firm consistency, and of a very delicate inner membranous lining forming the immediate continuation of the skin of the body. Between these 2 lamellæ some internal organs are continued, viz., the ovarial tubes and the cæca of the intestine (see fig. 4).

The shell, in the living state of the animal, exhibits a yellowish green colour, dotted with darker green, and has moreover, dorsally, as also at each extremity, irregular shadows of a much darker hue, forming partly interrupted transverse bands (see figs. 1 and 2). On each side of the shell, behind the central muscular area, may generally be observed a more or less distinct orange tinge, produced by the ripe ova accumulated within the underlying body, and a dark diagonal stripe is also seen running from the upper side of the muscular area obliquely backwards. This stripe forms the boundary between the ovarial tubes and the cæca of the intestine, both lying, as above stated, between the two lamellæ of the valves.

When the one valve is carefully detached[1], the enclosed animal can be to some extent examined in its natural situation lying within the other valve (see fig. 3). It is thereby easily demonstrated, that the body does not nearly fill

[1] This may be best accomplised by previously killing the animal in boiling water, when the valves will remain wide open, and the several appendages extended in their natural position.

the inner cavity of the shell, and that sufficient room is left for all the appendages, when drawn in by the animal on closing its shell. During the movements of the animal, however, both pairs of antennæ, as also generally the anterior pair of legs, and at times the caudal rami are seen to extend from the shell. The body is attached to the shell along the whole dorsal face and also laterally by the great adductor muscle, in such a manner, that only its hindmost part is freely movable within the shell. In front the body appears, as it were, transversely truncated, and any boundary between the head and trunk does not exist, nor is the abdominal division defined from the trunk by any intervening suture or constriction. There is consequently no distinctly pronounced segmentation of the body, and the number of segments that originally compose it, can therefore only be determined by the number of limbs. This is rather restricted, being only 7 pairs in all, viz., 2 pairs of antennæ, 1 pair of mandibles, 2 pairs of maxillæ, and 2 pairs of legs. Quite in front, and at a short distance from the dorsal face, the eye occurs, and may also be fairly well traced through the shell. Immediately beneath it, the superior antennæ issue, acting, during the motions of the animal, upwards and backwards. At some distance below them, the doubly-geniculated inferior antennæ originate, acting in an opposite manner to the superior ones, viz., downwards and backwards. Between the bases of those antennæ the voluminous anterior lip is seen to project, forming in front an obtuse prominence. The oral aperture is found ventrally at a considerable distance from the bases of the inferior antennæ, and on the sides of it are seen the bodies of the mandibles, with their masticatory parts wedged in between the anterior and posterior lips, whereas their distal parts extend up the sides of the body to above the middle. The strong mandibular palps issuing from the outer faces of the mandibles extend obliquely forwards and downwards between the bases of the inferior antennæ and the oral aperture, their branchail appendage, however, being generally extended in the opposite direction. Behind the oral aperture the anterior maxillæ are easily observed, with their digitiform masticatory lobes, and the likewise digitiform palp extending obliquely forwards towards the mouth. To the outer side of these maxillæ is attached, the large semilunar branchial plate extending obliquely upwards. Close behind these maxillæ the posterior ones may be partly traced, with their flabelliform reflexed palps. Then follow close together the 2 pairs of legs, the anterior of which are generally extended from the shell below, acting anteriorly, whereas the posterior ones are constantly kept within the cavity of the shell, and more or less bent up across the abdominal part of the body. Between the legs and the insertion of the caudal rami is a rather long interval, of which the greater part is occupied by the genital lobes. The caudal rami are very movably articulated to the end of the abdominal part of the body, and from the articulation a strong chitinous stripe is seen extending along each side of that part, strengthening the articulation. When at rest, the caudal rami are generally extended straight forwards, being applied against the ventral face of the body. By the aid, however, of a number of strong muscles running along the dorsal side of the abdominal part of the body, and joining their base posteriorly, they can be suddenly moved downwards and backwards so as to extend in the direction of the axis of the body, thereby serving as a most effective propulsive apparatus.

I will now proceed to a more detailed description of the above-mentioned parts.

The eye (see Pl. 1, fig. 3), which undoubtedly, both as regards place and structure, corresponds to the *ocellus* in other Entomostraca, is of a rounded quadrate form, and contains a very dark pigment. Its lateral faces are highly refractive, exhibiting in the living animal a very brillant iridescent lustre, and are apparently each divided into two facets. The eye is to a certain extent movable, permitting of a slight revolving motion accomplished by the aid of 2 thin muscles joining it on each side from behind.

The superior antennæ (Pl. 2, fig. 1) are each composed of a thick and muscular basal part and a narrow, multi-articulate terminal part or flagellum. The basal part issues from the front part of the body by a broad base, and has the upper face vaulted, the lower nearly plain. It is composed of 2 joints, the proximal one being much the larger, and strengthened by several chitinous stripes anastomosing with each other. From about the middle of the upper side of this joint issues an anteriorly curving simple bristle, and at the end below, two other considerably longer reflexed setæ are seen to extend. The rather short and narrow distal joint is only provided with a very small bristle anteriorly, and would seem to be rather firmly connected with the proximal joint. The flagellum, or terminal part of the antennæ, is nearly of the same length as the basal part, to which it is very movably articulated, but is much narrower, and subcylindric in form. It is divided into 5 well-defined articulations, the 1st of which is much the largest. From the end of the articulations issue long setæ, forming together a dense brush. It is, however, not easy to count the setæ, as they generally lie very close together;

but, excepting the 1st articulation, which has only 2 comparatively short setæ, each articulation would seem to give origin to 4 natatory setæ, 2 anteriorly and 2 posteriorly, the former being particularly elongated. The last articulation, moreover, has 2 or 3 shorter, spine-like bristles on the tip. During the swimming motions of the animal, the setæ are spread out in such a manner as to form a broad fan, and as they are all finely ciliated, these antennæ may act as most effective propulsive organs.

The inferior antennæ (fig. 2) are comparatively more strongly built than the superior, and pediform in character. They also consist of a basal and a terminal part, forming together a strong geniculate bend. The basal part, as in the superior antennæ, is bi-articulate, but the distal joint is here much the larger, whereas the proximal one is quite short and less distinctly defined from the body. Both joints are strengthened by several chitinous stripes curved in different directions, and between them is a more movable articulation than between those of the superior antennæ. The proximal joint carries below 2 or 3 short bristles, and from the end of the distal joint issues posteriorly a slender reflexed seta, and anteriorly, somewhat inside the joint, another still longer seta, which curves downwards in front of the terminal part. The latter, which is very movably articulated to the basal part, is composed of only 3 joints. The 1st joint is fully as long as the distal joint of the basal part, but considerably narrower, and carries at some distance from the base posteriorly a peculiar sensory appendage terminating in a very delicate cylindric papilla (fig. 2, b). At the end, this joint has posteriorly a single, strong ciliated seta, whereas anteriorly, and somewhat inside the joint, 5 or 6 very slender and elongated setæ issue close together, curving downwards in front of the outer joints, and extending as far as the tips of the terminal claws. These setæ are finely ciliated, and during the swimming motions of the animal, are spread in a fan-like manner, to counterbalance the effect of those issuing from the superior antennæ. The 2nd joint of the terminal part is but little more than half as long as the 1st, and also considerably narrower, forming with the same a more or less pronounced geniculate bend. It is provided on each side, about in the middle, with a fascicle of slender bristles, and is produced at the end anteriorly to a knob-like projection carrying 3 very strong claws of somewhat unequal length. The last joint is very small, and apparently firmly connected with the 2nd. It is (see fig. 2, a) of simple cylindric form, and carries on the tip 2 unequal claws, and 3 small, hair-like bristles. The claws are much smaller than those issuing from the preceding joint, which in fact extend somewhat beyond them.

The anterior lip (figs. 3, 4) is rather voluminous and produced in front in a hood-like manner. It terminates posteriorly with a sharpened edge limiting the oral aperture in front. Within it, several muscles are seen to spread, which may serve for lifting it to a certain extent; and a rather complicated system of chitinous stripes anastomosing with each other, and partly continued around the oral aperture, may also be distinctly traced.

The posterior lip (ibid. and fig. 5) is in the form of a thin plate bounding the oral aperture behind, and placed almost vertically. It is strengthened on each side by a very strong chitinous rod, which expands at the end to a dark horn-coloured lamella, divided into 7 or 8 coarse denticles. This lamella is placed transversally, and is somewhat incurved, so as to meet the one on the other side. Between the 2 chitinous rods, a close striation is observed (see fig. 5), and along the middle, a funnel-shaped depression occurs, leading to the œsophagus.

Immediately behind the posterior lip, the ventral face of the body forms a somewhat prominent carinated plate, lying between the insertions of the maxillæ.

The mandibles (fig. 6) each consist of a strongly chitinized body, and a well-developed pediform palp. The body is of a somewhat cuneated shape, its upper part being produced to an acute point, which is apparently articulated to the inside of the shell. The dark horn-coloured masticatory part is slightly incurved, and has exteriorly a small bristle. The cutting edge is divided into 6 or 7 strong, dark brown teeth, diminishing in size inwards, and coarsely denticulated in their outer part, having between them stiff bristles. The palp is about half the length of the mandible, and is curved downwards. It consists of 4 well-defined joints, the 1st of which is rather large, and carries at the end posteriorly 3 very strong and densely ciliated setæ. To the outer side of this joint a comparatively small, recurved branchial appendage is attached, carrying 6 densely plumous setæ, 4 of which issue from the transversely truncated tip, whereas the 6th is secured to a separate ledge on the outer edge. The 2nd joint of the palp is rather short, and carries both anteriorly and posteriorly several slender bristles. The 3rd joint is much larger, and is likewise provided on both edges with a fascicle of bristles. Finally, the last joint is very small and somewhat conically tapered, and carries on the tip 3 or 4 short, spiniform bristles.

The anterior maxillæ (fig. 7) each exhibit a thick and muscular basal part, to the outer side of which is attached a very large semilunar branchial plate, which in the living animal is seen to exhibit rhythmical vibratory movements. The plate is provided along its outer edge with about 24 exceedingly strong and densely plumous setæ, of which the 5 inferior ones are curved straight downwards. From the end of the basal part issue 4 digitiform lobes, the most anterior of which is much the largest, and is movably articulated to the basal part. This lobe, which ought more properly to be regarded as the palp, consists of 2 well-defined articulations, the 1st of which is the larger, cylindric in form, and provided at the end anteriorly with a number of slender curved bristles. The distal joint (see fig. 7, a) is rather short and very slightly expanded at the end, which is obliquely truncated and armed with about 6 claw-like bristles. The 3 other lobes, the true masticatory lobes, are quite simple, diminishing successively in size, and each carrying at the tip a bunch of strong, partly denticulated spines.

The posterior maxillæ (fig. 8) are much smaller than the anterior, and of a rather different structure. The basal part is immediately continued as a simple masticatory lobe extended obliquely forwards, and armed at the tip with a dense bunch of slender spines, having also inside, at some distance from the tip, some few similar spines. From the posterior side of the basal part issues a conically tapering lappet, which is extended straight backwards and terminates in 3 setæ, of which the middle one is much longer than the other 2. This lobe ought to be regarded as a peculiarly modified palp. Immediately above it a small rounded branchial plate is secured, carrying 6 densely plumous setæ.

The anterior legs (fig. 9) are rather strongly built, and consist each of a short and thick basal part and a more slender, tapering terminal part. The basal part is strengthened by several chitinous stripes, and seems to consist of 2 imperfectly defined joints, forming together a geniculate bend, from which a few small bristles are seen to issue. The terminal part is divided into 4 well-defined joints, the 1st of which is much the largest and about as long as the 2 succeeding ones combined. It contains several strong muscles joining the very movable outer part of the leg, and carries at the end anteriorly a simple bristle. The 2 next joints are firmly connected, though defined by a distinct transverse suture, and have each at the end anteriorly a similar bristle to that of the 1st joint. The last joint is very small, and carries on the tip an exceedingly long and slender, anteriorly curving claw, at the base of which 2 small bristles are secured.

The posterior legs (fig. 10) are considerably more slender than the anterior, and are apparently only composed of 4 joints, though a short basal joint may probably exist The 1st joint is somewhat bent in the middle, and carries 3 slender setæ, 2 of which issue from near the end, whereas the 3rd is attached to the middle of the lower edge. The 2nd joint, which forms with the 1st a strong elbow-like bend, is very much elongated and narrow cylindric in form, having a single slender bristle at the end posteriorly. The 3rd joint is much shorter and also narrower than the second, being somewhat constricted at the base. It carries, in the middle of the posterior edge, a slender bristle, and juts out at the end to a short, thumb-like projection. The last joint is extremely small, and is produced to a strongly-curved claw extending backwards, and having at its base a slender bristle pointing in the opposite direction. The function of these legs is apparently that of cleansing the inner cavity of the shell from extraneous matter, for which reason these legs are generally termed in the German language »Putzfüsse».

The genital lobes (see figs. 11 and 12) occurring between the posterior legs and the insertion of the caudal rami, constitute 2 juxtaposed, transversely oval expansions. At their posterior end the genital orifice seems to occur, and a number of distinct muscular fibres are seen to converge to this place. Farther in front, and somewhat inside the lobes, there is a funnel-shaped hollow bounded by some strong, curved chitinous stripes, and immediately above it may be traced, a peculiar orbicular body, which, on a closer examination, is found to be formed by a narrow duct coiled up into numerous dense spiral coils, and finally joining the above-mentioned hollow. Zencker has explained these hollows as the »vulvæ«, and the coiled duct to be destined for the passage of the thread-like zoosperms, believing that the receptacula seminis are in direct communication with this duct. I am by no means convinced of the correctness of this explanation. In the present form, not the slightest trace of any »receptacula seminis«, is to be found, and I should therefore be more inclined to believe that the duct is in reality destined to secrete a viscid fluid, from which the egg-shell may be formed.

The caudal rami (see figs. 12, 13) are rather strongly developed, fully equalling in length the free abdominal part of the body. They are in the form of 2 juxtaposed narrow plates, which, however, at the base are united (see fig. 12). Each ramus is armed at the end with 2 strong claws, and has the outer half of the dorsal edge divided into 4 or 5 slight lobes edged with a comb-like series of strong denticles (see fig. 13 a). Of the claws the apical one is fully twice as long as the other, though not attaining half the length of the ramus. Both claws are but very slightly curved, and are finely denticulated along their concave edge. Just in front of the apical claw issues from the tip of the ramus a rather long bristle curving downwards in front of the latter, and another much smaller one is seen attached to the dorsal edge, immediately above the other claw.

Inner organs.

In order to examine the inner organs in their natural situation, it may be convenient to detach the animal carefully from its shell, and to place it for some time in absolute alcohol, then either transferring it to oil of cloves at once, or after having previously stained it very slightly with hæmatoxylin or carmine. The animal may then be mounted in canada balsam either entire or in parts. Some of the inner organs, especially those contained within the lamellæ of the valves, may however be equally well examined in quite fresh specimens.

The intestinal canal commences with a muscular œsophagus ascending perpendicularly from the oral aperture, and joining the intestine proper by a somewhat tumefied part strengthened, according to Zencker, by several chitinous lamellæ. The intestine proper (see pl. 1, fig. 3) is very capacious, occupying a great part of the inner cavity of the body. It is divided into two very sharply defined parts, one anterior, the stomach, and one posterior, the gut these being separated by a strong constriction occurring about in the centre of the body. The stomachal portion is produced above to a large rounded sac advancing over the anterior part of the gut, and sends off from each side, immediately above the adductor muscle of the shell a cylindrical cæcum, the so-called liver-sac. The latter immediately penetrates between the 2 lamellæ of the valves, extending in each of them diagonally to the hind extremity (see fig. 4). These cæca are lined internally with large secretory cells, and generally exhibit a more or less brownish hue. In the living animal at times a rhythmical peristaltic movement of these cæca may be observed, which caused Fischer to regard them erroneously as hearts. The posterior part of the intestine, the gut, is also rather capacious, and extends through the abdominal division of the body, terminating in a short rectum, which debouches immediately in front of the insertion of the caudal rami. It is generally found to be filled with a dark matter, whereas those of the stomachal part always appear considerably lighter. The walls of both the stomachal and abdominal parts of the intestine are strongly muscular, and during life both parts are seen to perform rather energetic movements.

The circulatory system is very imperfect. There are no blood-vessels whatever, and not even the slightest trace of a central organ, a heart, is to be detected. The colourless blood is contained in the interstices between the inner organs, and is put in motion, it would seem, chiefly by the movements of the intestine.

The respiratory system is represented by 3 pairs of delicate, setiferous lamellæ appended to the mandibular palps and the 2 pairs of maxillæ. These lamellæ, which in the living animal are in rhythmical vibratory motion, are therefore generally termed branchial appendages. It is, however, most probable, that these appendages are in fact only subservient to the respiration, and that the latter process (the exchange of gases) takes place chiefly in the delicate inner membrane of the valves. By the rhythmical movements of the branchial lamellæ, and especially of those of the anterior maxillæ, a continous renewal of the water takes place within the cavity of the shell, whereby a sufficient aëration of the blood contained between the two lamellæ of the valves may be obtained.

The nervous system I have not been able to examine more closely, nor could Zencker observe it in its totality, owing to its concealed situation, though the upper æsophageal ganglion, and another larger one lying behind the oral aperture were to be faintly traced.

Of the genital system, only the female organs can be described here, as I have never come across a male specimen. In all probability males do not exist at all. The ovaria consist of a slender tube on each side contained between the lamellæ of the corresponding valve, and extending immediately above the liver-sac (see fig. 4). This tube gradually tapers distally, and its blind end forms an abrupt curve upwards. At nearly the same place, where the liver-sacs join the intestine, the ovaria pass into the body, forming in the abdominal part on each side a capacious cavity, into which the ripe ova are received. Within the ovarial tubes egg-cells in every stage of development may be observed (see fig. 4). In the hindmost blind ends, a great number of simple nuclei are accumulated. Farther in front, each nucleus has become surrounded with a clear yolk-matter, and the several cells are here more clearly defined, being arranged in several series. By the successively increasing size of the cells more anteriorly, only a double series can be discerned, and at last there is only room for a single series of egg-cells successively increasing in size. The cells lying in the foremost part of the ovarial tube become gradually filled with an opaque orange matter, the nutritive yolk, and are now nearly ripe. They are successively received into the egg-cavities of the body, and there often accumulate in rather large numbers, being at intervals expelled through the genital openings. All the ova contained in the said egg-cavities are of exactly the same size and in the same stage of development; and these cavities cannot therefore properly be regarded as a part of the ovaria themselves, but only as a sort of reservoir for the eggs. They are still only surrounded with a very thin, pellucid, vitelline membrane, without any trace of the strong, coriaceous capsule, which is found enveloping the deposited ova. This capsule must accordingly be formed immediately after the ova have passed through the genital openings.

Biological Observations.

At first only some few specimens of this form made their appearance in one of my aquaria rather late in the autumn. They thrived very well, and soon reached maturity, whereupon they began to deposit their eggs in small clusters, chiefly on pieces of weed contained in the mud. The eggs after some time developed into young ones, which in their turn became adult, and in the same parthenogenetical manner as the first hatched specimens, gave origin to a third generation. The aquarium contained this Ostracod during the whole winter, and though from time to time a considerable number of specimens were taken out and preserved, some specimens yet remain in the aquarium. All specimens, without exception, were of the female sex, and I do not doubt therefore, that this form, like several of its allies, is exclusively partenogenetical in character.

As to habits, it is more generally found on the bottom of the aquarium, moving about rather quickly through the loose mud. Now and then however, it is, seen to ascend the walls of the aquarium in search of food, and at other times to swim rather rapidly through the water in a similar manner to that observed in the species of *Cypris*. It is, however, on the whole less active than these forms, and in this respect holds the mean between the species of *Cypris* and *Candonocypris*.

Occurrence.—The mud from which this form was raised, was from only one of the two samples received, viz, that taken from the swamp of Bon Kamera.

A Short Account of the various Entomostraca Raised from the Two Samples of Mud.

Cladocera.

1. Daphnia magna, Strauss.

This well-known form developed in great numbers in two of my aquaria, both prepared with mud from the swamp of Bon Kamera. It was watched during 2 or 3 successive sexual periods, and in the one aquarium is still living.

2. Ceriodaphnia reticulata (Jurine).

This form also developed rather plentifully in one of my aquaria, but the mud from which it was raised belonged exclusively to the other sample, viz., that taken from the swamp of Kharezas.

3. Ceriodaphnia minor, Lilljeborg.

Of this species, which is very nearly allied to the preceding one, but of a much smaller size, numerous specimens developed in two of my aquaria, both prepared with mud from the Bon Kamera swamp.

4. Simocephalus vetulus (Müller).

This well-known form developed very abundantly in one of my aquaria, and was watched during 2 successive sexual periods, male specimens being at the close of each period very numerous. The mud belonged to the sample taken from the swamp of Bon Kamera.

Trykt den 8de Oktober 1896.

5. *Leydigia acanthocercoides* (Fischer).

A single adult female specimen of this Lynceid was taken up from the same aquarium, in which *Simocephalus vetulus* occurred. It was not, however, observed subsequently.

6. *Alona lineata*, Fischer.

Of this species, very seldom met with in Norway, countless myriads developed in all my aquaria.

7. *Chydorus sphæricus* (Müller).

Found rather frequently together with the preceding species.

Ostracoda.

8. *Cypris virens*, Müller; var. *monilifera*.

This variety, distinguished by a number of rounded nodules at each extremity of the valves, not found in the typical form, developed in two of my aquaria prepared with mud from the swamp of Bon Kamera.

9. *Stenocypris Chevreuxi*, G. O. Sars.

See above.

10. *Ilyocypris australiensis*, G. O. Sars.

Several specimens of an Ilyocypris not distinguishable from the Australian form described by the present author in his paper »On some Australian Ostracoda and Copepoda«, were raised in one of my aquaria prepared with mud from the same locality as the 2 preceding species.

11. *Ilyocypris gibba* (Rhambdor).

Of this species, easily distinguished from the preceding one by the gibbous projections of the valves, a few specimens were raised from mud derived from the other locality, viz., the swamp of Kharezas.

Copepoda.

12. *Diaptomus.* sp.?

This is a very small species, which I cannot identify with any of the forms described by M. de Guerne et Richard, but which seems to come nearest to *D. graciloides*, Lilljeborg. It was raised in two of my aquaria prepared with mud from the swamp of Bon Kamera, and a considerable number of specimens preserved in spirit was also sent me by M. Chevreux from the same locality.

In addition to the above enumerated Entomostraca some colonies of a fresh-water Bryozo, *Plumatella repens*, Lin, also developed in one of my aquaria prepared with mud from the swamp of Kharezas.

Explanation of the Plates.

Pl. I.

Stenocypris Chevreuxi, G. O. Sars.

Fig. 1. Adult female, viewed from right side, magnified 39 diameters.
» 2. Same, dorsal view, magnified 39 diameters.
» 3. Left valve with enclosed animal, the right valve being detached, lateral view; magnified 45 diameters.
» 4. Right valve of same specimen, viewed from the inner face, and exhibiting the corresponding liver-sac and ovarial tube; magnified 45 diameters.

Pl. II.

Stenocypris Chevreuxi, G. O. Sars.
(continued).

The greater part of the figures magnified 88 diameters.

Fig. 1. Superior antenna.
» 2. Inferior antenna.
» 2. a. Terminal joint of same, more highly magnified.
» 2. b. Sensory appendage from same, likewise highly magnified.
» 3. Anterior and posterior lips, seen from below.
» 4. Same parts, exhibited from right side.
» 5. Posterior lip, more highly magnified, and viewed from the anterior face.
» 6. Mandible with palp.

Fig. 7. Anterior maxilla with branchial plate.
» 7 a. Extremity of palp, more highly magnified.
» 8. Posterior maxilla.
» 9. Anterior leg.
» 10. Posterior leg.
» 11. Right genital lobe, seen from the outer face.
» 12. Extremity of body, with the genital lobes and the extended caudal rami, viewed from the ventral face.
» 13. One of the caudal rami, seen laterally.
» 13. a. Outer part of the dorsal edge of same, more highly magnified.

DESCRIPTION

OF TWO NEW

PHYLLOPODA

FROM

NORTH AUSTRALIA

BY

G. O. SARS

WITH 6 AUTOGRAPHIC PLATES

ARCHIV F. MATHEM. OG NATURVIDENSKAB

KRISTIANIA
ALB. CAMMERMEYERS FORLAG
LARS SWANSTRØM

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Description of Two New **Phyllopoda** from North Australia.

With 6 autographic Plates.

By G. O. Sars.

Introduction.

In a previous paper inserted in this journal, I have given descriptions and figures of 5 species of Phyllopoda collected by Messrs. Whitelegge and Lea in the neighbourhood of Sydney, all of which have been identified with earlier recorded forms. I now propose to describe 2 additional Phyllopoda from the northern part of the continent. The total number of Australian Phyllopoda, including *Cyclestheria Hislopi*, Baird, previously described by the present author, and some forms recorded by Messrs. King, Baird and Brady, thus amounts to no less than 10 in all, belonging to the 3 leading sections of the sub-order: *Anostraca, Notostraca,* and *Conchostraca.* Of the 2 species described in the present paper, the one has been observed by myself in a living state, whereas the other is described from well-preserved alcoholic specimens. Both of these forms I regard as new to science.

Trykt den 8de Oktober 1896.

Section **Anostraca.**

Fam. Branchipodidæ.

Gen. **Streptocephalus**, Baird.

Remarks.—This genus was established by Baird in the year 1852, and is chiefly characterised by the peculiar structure of the male prehensile antennæ. As I have only found the Australian species described below in the female sex, I have been somewhat in doubt as to its true systematic place among the Branchipodids. In its external appearance it shows, however, a rather close resemblance to the female of the species *Streptocephalus similis* from St. Domingo, and as it seems to differ in some points rather markedly from the females of other Branchipodid genera, I have felt justified in referring it provisionally to the above-named genus.

Streptocephalus Archeri, G. O. Sars, n. sp.

(Pl. I).

Specific Characters.—Female. Body very slender, with the anterior division about the length of the posterior (excluding the caudal rami). Head exhibiting on the dorsal face a small, but well-defined rounded quadrangular and somewhat elevated area. Eyes comparatively large, pyriform, with the corneal part globularly expanded and the pigment very dark. Ocellus small. Antennulæ narrow and elongated. Antennæ about the length of the antennulæ, applanated, foliaceous, not compressed, and having at the obtusely rounded tip a very short pointed projection. Legs apparently of the usual structure, outer part of endopodite broadly rounded, exopodite lamelliform, much smaller on the 1st than on the succeeding pairs, basal plate minutely and regularly serrated. Marsupium rather short and narrow, scarcely reaching beyond the 2nd caudal segment; enclosed ova of a very peculiar shape, being each surrounded by a tetrahedric shell. Caudal rami very much elongated, being about half the length of the tail proper, and rather narrow, tapered distally, and fringed all round with strong plumous setæ. Body, in the living state of the animal, highly pellucid, nearly colourless, caudal rami, however, tinged with a vivid reddish orange; eggs in the marsupium dark horn-coloured. Length of the adult female 9 mm.

Remarks.—As above stated, this form shows some resemblance in its external appearance to the female of *S. similis*, as figured by Baird, though being still more slender, and having the caudal rami comparatively longer. Moreover, the marsupium is shorter, and the enclosed ova apparently of a very different shape.

Description of the female.

The length of the solitary adult specimen examined is about 9 mm., measured from the front to the tip of the caudal rami, and this form is accordingly somewhat inferior in size to the other known species of the genus.

The body (see Pl. I, figs. 1, 2) is extremely slender, resembling in this respect the species of the genera

Branchinecta and *Artemia*. It shows its 2 chief divisions well defined, both being about of the same length The anterior division may be subdivided into the head and the trunk, the posterior one into the genital part and the tail proper.

The head is not very large, and but slightly deflexed, carrying in front the 2 pairs of antennæ, laterally the eyes, and ventrally the oral parts. By a distinct transverse suture extending dorsally between the upper ends of the mandibles it is divided into an anterior and a posterior part, the latter representing the so-called cervical segment. The anterior part seen from above (fig. 1), is almost pentagonal in form, and exhibits in the middle of the dorsal face a small, but well-defined, rounded quadrangular area, which, in a lateral view of the animal (fig. 2), is found to be slightly protuberant. This area may also be observed in other Branchipodids, and would seem to answer to the postocular tubercle in the *Notostraca* and the affixing organ in some of the *Conchostraca*. The cervical segment carries ventrally the 2 pairs of maxillæ, and exhibits on each side a contorted duct, which undoubtedly answers to the so-called shell-gland in other Phyllopods.

The trunk is somewhat broader than the head, slightly depressed, and divided into 11 uniform segments, each carrying a pair of branchial legs. Seen dorsally (fig. 1), it appears somewhat fusiform in outline, being broadest in the middle, and slightly tapering both anteriorly and posteriorly.

The posterior division of the body is considerably narrower than the anterior. Its first 2 segments form together the genital division, and are coalesced in the greater part of their extent, being only distinctly defined dorsally. From this region proceeds ventrally the marsupium, or ovisac, the free end of which is extended backwards in the form of a somewhat conically tapered tube, having at the tip a valvular opening, through which the ova are expelled, when mature. This free part of the marsupium is rather short, scarcely reaching beyond the 2nd segment of the tail proper. The latter is very narrow, cylindric in form, and is divided into 7 well-defined segments, the last of which is very short, and slightly produced in the middle, where the anal orifice occurs (see fig. 1). To this segment the caudal rami are attached, being extended posteriorly and more or less diverging.

The eyes (see figs. 1, 2, 3) are rather large, and move freely, extending generally more or less straight laterally, immediately behind the insertions of the antennæ. They exhibit a pronouncedly pyriform shape, being considerably constricted at the base, and gradually widening distally. The eye-ball proper, occupying the extremity of the eye, is globularly expanded, and exhibits a very great number of visual elements radiating from the dark pigment and forming a clear zone around it.

The ocellus (ibid.) is very small, and occurs in the middle of the foremost part of the head as a punctiform, dark red pigmentary spot.

The 1st pair of antennæ, or the antennulæ (see figs. 1, 2, 3), are rather slender and elongated, in length considerably exceeding the head, and in the living animal are generally extended anteriorly and somewhat divergent. They are of a very delicate structure, narrow cylindric in form, and slightly tapering towards the tip, which carries a number of small olfactory papillæ, and a single somewhat longer sensory bristle.

The 2nd pair of antennæ, or the antennæ proper (ibid.), are in the form of 2 flattened (not as in most other Branchipodids compressed), foliaceous lamellæ, generally extended straight downwards. In length they about equal the antennulæ, and are about twice as long as they are broad. The tip is evenly rounded, and exhibits, about in the middle, a very small pointed projection. Otherwise the edge is evenly curved, and provided with extremely delicate, small sensory hairs. Within the base of each antenna enters from the head a muscular bundle, which soon divides into numerous fine, diverging branches (see fig. 3). Any essential significance however, this muscle does not seem to have, as the antennæ are scarcely movable, and generally keep their prone attitude nearly unaltered during life.

The anterior lip is easily observable in a ventral or lateral view of the animal (fig. 2), forming a flap-shaped expansion covering over the masticatory parts of the mandibles, though admitting of being somewhat removed from them ventrally.

The mandibles also appear very distinctly in the lateral view of the animal (fig. 2), lying like a pair of much bent bows on each side of the head, at the limit between its anterior part and the cervical segment, and meeting ventrally at the place where the oral aperture occurs.

The maxillæ, in the lateral aspect of the animal, are hidden by a lobular expansion of the cervical segment, containing the lower part of the shell-gland (see fig. 2).

Of branchial legs there are, as in all true Branchipodids, 11 pairs, all of a rather uniform structure, though somewhat diminishing in size both anteriorly and posteriorly. They are pronouncedly laminar in character, and are extended downwards and somewhat laterally, with the anterior face more or less vaulted, the posterior, concave. On all the legs the following parts are to be distinguished: the stem proper, or endopodite, the exopodite, the epipodite, and the basal plate, the last 3 issuing from the outer side of the stem (see fig. 5). The endopodite is rather broad and laminar, and terminates in a comparatively large, broadly-rounded lobe, edged with short, ciliated setæ. Above this lobe issue, from the inner edge of the endopodite, 5 other lobes, the 3 outermost of which are rather small and conical, and are each tipped with a limited number of slender setæ (from 3 to 6), some of them rather short and curved inwards. The 2nd lobe from above is somewhat broader and more evenly rounded at the tip, and the uppermost one is much larger still and fully as broad as the succeeding 4 combined. Both these lobes are fringed with a dense and regular series of slender, biarticulate setæ curving inwards and upwards in a falciform manner. Of the above lobes, the uppermost would seem to answer to the coxal lobe in other Plyllopoda, whereas the others represent the so-called endites. The exopodite forms an oval lamella movably articulated to the endopodite, outside its terminal lobe, beyond which it extends considerably. The lamella is edged all round with ciliated setæ increasing in length distally, their number being from 30 to 40. The epipodite is attached at some distance above the exopodite, and has the character of a vesicular lamella of a somewhat spongeous structure, and without any armature whatever. The basal plate issues from the upper part of the endopodite outside, and is very thin and pellucid, of a somewhat elliptical form, with the outer edge finely and regularly serrated. Of the above-described parts, the epipodite undoubtedly represents the true gill; but we have reason to believe that respiration takes place also in the other parts of the leg, which all exhibit a very delicate membranous structure. Inside the endopodite, numerous muscular bands are seen extending in different directions. Some of them join the exopodite, which is the most freely movable appendage, being found now extended in the axis of the leg, now considerably incurved beneath the terminal lobe of the endopodite. Between the muscles a number of opaque, somewhat stellate patches are seen scattered over the greater part of the endopodite. These patches are produced by a corresponding number of cross-bars connecting the 2 lamellæ composing the leg, and thereby a system of internal hollows is formed, in which the blood circulates. A similar structure may also be found on other parts of the leg, and especially very distinctly in the epipodite.

The above description applies to the greater number of the legs. Only the first and last pairs exhibit some minor differences, to be mentioned below.

In the 1st pair the exopodite is considerably smaller than in the others, not extending at all beyond the terminal lobe of the endopodite, which appears rather broad in proportion to its length (see fig. 4).

The last pair of legs (fig. 6) differ from the others in the fact, that the terminal lobe of the endopodite is somewhat less developed, whereas the exopodite is fully as large as in the preceding pairs. Moreover, the inner lobes of the endopodite are considerably reduced in size, and only supplied with scattered and rather short bristles. The basal plate is likewise comparatively smaller than on the other legs; and finally, the epipodite has lost its spongeous character, and assumed a structure similar to that of the basal plate, its terminal edge even being divided into a number of distinct serrations.

The caudal rami (see figs. 1, 2) are considerably elongated, attaining about half the length of the tail proper. They are rather narrow, gradually tapering distally, and are all round fringed with strong ciliated setæ, springing off from distinct ledges of the edge. By the aid of some muscular bundles joining their bases, they admit of being to a certain extent spread out and again brought together.

Of inner organs, the intestine is very clearly traced through the pellucid integuments (see figs. 1, 2), extending as a cylindric tube through the axis of the body. It is a little wider in front than behind, and sends off in the head anteriorly 2 small rounded cæca of apparently quite a simple structure. The rectum is very short, and confined to the last caudal segment.

Immediately above the intestinal tube, the very long vessel-like heart may easily be traced in the living animal, exhibiting in each segment a pair of venous ostia.

The ovaria were not distinctly visible in the solitary adult specimen examined, apparently owing to the recent evacuation of their contents into the marsupium. It would, seem, however, that they are confined to the posterior division of the body, as not the slightest trace could be detected in the trunk, whereas in the tail several scattered cellular bodies, apparently belonging to these organs, occurred on each side of the intestine (see figs. 1, 2). At the base of the marsupium an irregular glandular mass was distinctly observed, apparently of the same kind as that furnishing in other Branchipodids the material for the egg-shell.

The ripe ova contained in the marsupium are, in this form, of a highly remarkable appearance. They are (see figs. 7, 8, 9) each enclosed within a rather large and firm,

Trykt den 9de Oktober 1896.

horn-coloured capsule of a trigonal, or more correctly tetrahedric shape, exhibiting 4 plane or very slightly concave faces of exactly the same size and form, and connected by obtuse, prominent ribs. As far as I know, in no other Branchipodid has a similar form of the egg-capsules been observed. In all the previously known forms, the eggs are simple globular bodies, and it is only in some of the bivalve Phyllopoda, for instance in *Limnadia,* that an analogous structure of the egg-capsules occurs.

The body in the living animal was highly pellucid and nearly colourless, with only a very faint yellowish tinge on the branchial legs. The caudal rami, however, exhibited a most pronounced vivid reddish orange colour.

Biological Observations.

The above described specimen was raised by the present author in the summer of 1886 from dried Australian mud, and was watched for some time in a small aquarium. The larval stages, however, wholly escaped my observation, and the animal, when first detected, had already attained a rather advanced stage of development, though still without any trace of a marsupium. After the lapse of some time, the marsupium was formed, and a number of the peculiarly formed eggs soon made their appearance within it. At this time, however, the aquarium unfortunately became so encumbered with confervous growth, that the animal was considerably impeded in its free movements, and as it showed signs of disease, I hastened to secure it, after having previously made 2 carefully executed and coloured drawings (the ones here reproduced) from the animal when still alive. Though I carefully preserved the residue of the aquarium for later hatching operations, no specimens developed subsequently.

Probably the specimen had not yet deposited any ova in the mud.

When still in its full vigour, the animal was extremely rapid in its movements, twisting away in all directions, in most cases with the back downwards. The movements were effected partly by the aid of the rhythmically swinging branchial legs, partly by abrupt strokes of the very flexible tail, in which the densely setous caudal rami seemed to be of essential service.

Occurrence.—The mud from which the specimen was raised, was taken during the previous year by Mr. Archer from a water hole at Cattle Station—salt at high tides—20 miles from Rockhampton, Queensland. From the same sample of mud, several other Entomostraca were also raised, and have been described and figured by the present author in another paper. Some other specimens, apparently of the same Branchipodid, but all of them still immature, were recently received from Mr. Knut Dahl, who collected them together with the other Phyllopod here described, from a shallow pool on Mount Showbridge, near Port Darwin, North Australia.

Section **Conchostraca.**

Fam. Limnadiidæ.

Gen. **Eulimadia**, Packard.

Eulimadia Dahli, G. O. Sars, n. sp.

(Pl. II—VI).

Specific Characters.—Shell in both sexes of same appearance, very thin and pellucid, without any trace of umbones; seen laterally, of a rather regular elliptical shape, with the height but little more than $^2/_3$ of the length, dorsal margin evenly vaulted, and having its greatest convexity somewhat in front of the middle, ventral margin forming a perfectly even curve, and joining the anterior and posterior edges without any intervening angle, both extremities nearly equal, obtusely rounded at the tip, and having above a distinct angle:—seen from above, narrow fusiform, the greatest width in front of the middle. Maximum number of lines of growth only 4 pairs. Head having in both sexes the frontal part considerably produced; rostrum in female very short and obtuse, being only defined in front by a slight sinus; that of male considerably more prominent, terminating in an acute point. Antennæ and oral parts of the usual structure, excepting that the posterior maxillæ are quite rudimentary. Legs 20 pairs, having the epipodites of considerable size; the 2 anterior pairs in male very strong, subchelate. Tail with 2 short, juxtaposed dentiform projections in front of the caudal claws, the latter throughout the greater part of their length, fringed posteriorly with long ciliated setæ, caudal plates terminating below in a very acute, straight corner, and having the posterior edge divided into 12—16 small denticles; dorsal spines present only in a single distinctly developed pair. Eggs in the matrix provided each with a very uneven capsule divided into depressed hexagonal facets, the angles of which are acutely produced. Length of shell in female attaining 7 mm., in male 5.50 mm.

Remarks.—This is a true *Eulimadia*, exhibiting very pronouncedly most of the particulars referred to by Dr. Packard as distinguishing characters between this genus and that of *Limnadia*. It is very distinct from the Sydney species, *E. stanleyana* (King), described by the present author in his first paper on Australian Phyllopoda, and the latter form should perhaps more properly be regarded as the type of a separate genus, for which I would propose the name of *Paralimnadia*. The present form much more resembles 2 species recently described by the Japanese zoologist, Mr. Ishikawa, from the neighbourhood of Tokyo, as *E. packardiana* and *E. braueriana*. From both of these it differs, however, in the more oblong or elliptical form of the shell, and in the greater number of branchial legs. The species is named in honour of its discoverer, Mr. Knut Dahl.

Description of the female.

In the largest specimens examined, the shell attains a length of 7 mm., a height of 4.40 mm., and a width of 2.0 mm. It is accordingly rather larger than the 2 Japanese species, but does not nearly attain the large size of the

South Australian species, *E. rivolensis*, Brady, a form which is still, however, very imperfectly known, and perhaps does not even belong to this genus.

Seen from the side (Pl. II, fig. 1), the shell exhibits a rather regular oblong or elliptical form, and does not show even the slightest trace of any umbones. The greatest height of the shell occurs somewhat in front of the middle, and but little exceeds 2/3 of the length. The dorsal margin appears rather gently curved, and has its greatest convexity a little in front of the middle. It terminates both anteriorly and posteriorly in a well-marked angle, from which the free edges of the valves take their origin. These are evenly curved throughout, though anteriorly and posteriorly their curvature is somewhat stronger than in the middle. Both extremities of the shell appear obtusely rounded and nearly equal, or the anterior one very little broader than the posterior, having also the upper angle somewhat more pronounced.

Seen from above (fig. 2), the shell is found to be rather compressed, exhibiting a narrow cuneate or somewhat fusiform shape. Its greatest width, which does not attain half the height, occurs rather in front of the middle, and the posterior extremity appears considerably narrower than the anterior.

The valves are exactly alike, and exhibit a smooth and polished surface, without any trace of hairs or spines. They each have, however, a number of very delicate concentric striæ, the so-called lines of growth. These striæ, which lie somewhat closer together in front than posteriorly, do not seem to exceed 4 in number on each valve, and by the innermost a rather large oval area is defined, within which, somewhat anteriorly, the insertion of the adductor muscle of the shell occurs, and behind it the shell-gland extending obliquely downwards. The latter is constructed in exactly the same manner as in the European *Limnadia lenticularis*, Lin., though somewhat narrower and linguiform in outline.

The semipellucid shell admits of the enclosed animal being faintly traced through it (see fig. 1); but in order to examine it more closely in its natural situation, it is necessary to remove carefully one of the valves, leaving the animal within the other (see fig. 3), when the several parts may be submitted to a preliminary examination. It is found upon the whole to be constructed in a very similar manner to that described by the present author in *Paralimnadia stanleyana*. The dorsal ligament, however, by which the body is connected to the shell above, occurs here at a rather considerable distance from the anterior extremity, whereas in the Sydney species it is found close to the place where the free anterior edges of the valves take their origin. For this reason, the line of junction between the two valves in the present form is not only visible behind the ligament, but is continued in front of it to some extent, terminating at the upper anterior angle.

The anterior division of the body lying in front of the dorsal ligament, is generally strongly deflexed, though in the living state of the animal it may have been allowed to raise itself to some extent. The cervical segment is evenly convex above, and defined from the head proper by a rather deep depression, in the bottom of which a transverse suture occurs joining the upper ends of the mandibles. The head (see also Pl. III, fig. 1) is about the length of the cervical segment, and has the dorsal face strongly convex, carrying somewhat in front of the middle a well-defined affixing organ of a claviform shape. The frontal part of the head is narrowly produced, and its obtusely rounded extremity is to a great extent filled up with the large compound eyes. Below the frontal part, the head exhibits a rather slight sinus, and is produced behind this to a comparatively short and broad, obtuse-angled rostral expansion.

The trunk (see Pl. II, fig. 3) is more than twice as long as the anterior division of the body, and is extended straight backwards, with a very slight curvature downwards in its most posterior part. It is nearly cylindric in form, only slightly tapering distally, and is divided into 20 rather uniform segments, the last of which, however, is imperfectly defined from the caudal part (see Pl. III, fig. 3). Dorsally, the greater part of the segments are provided with transverse rows of posteriorly curving spiniform bristles, which successively disappear on the anterior segments.

The caudal part (see also Pl. III, fig. 3) is rather short and slightly deflexed, containing anteriorly the terminal part of the intestine, whereas posteriorly it is produced to 2 juxtaposed, thin lamellæ, the caudal plates, separated by a deep groove. These lamellæ each terminate below in a very acute spiniform corner, and have their posterior edge divided into 12—16 rather uniform, minute denticles. Between the lamellæ at their uppermost part there is a small tubercle carrying 2 slender ciliated bristles, the caudal setæ. Above these the dorsal face of the tail forms a heel-shaped convexity, which is armed with a single pair of strong, posteriorly curving spines. At the end in front, the caudal part is produced to two small, juxtaposed, dentiform projections, and immediately behind them the caudal claws are movably articulated to the tip of the tail. These claws are rather strong, somewhat exceeding the length of the tail, and are almost straight, with the greater part of their hind edge clothed with numerous long, ciliated setæ. The outmost part of the claws forms, as it were, a separate terminal joint, and has at the base a short spine, whereas its hind edge is throughout very finely denticulated.

The eyes (see Pl. III, fig. 1) are rather large and placed close together, so as to appear, in a lateral view of the animal, as a single organ. They exhibit each a great number of visual elements radiating from the dark pigment, and forming together a clear peripheric zone. Three narrow muscles pass from behind to each eye and allow that organ in the living animal to be moved to a certain extent.

The ocellus is placed at a considerable distance from the eyes within the rostral expansion, to the end of which it is connected by a short ligament, whereas another much longer ligament is seen to pass from its upper end and enter the frontal part, affixing itself to the skin of the head immediately below the eyes. The organ exhibits a similar prismatic shape to that found in the European *Limnadia lenticularis*.

The antennulæ (see Pl. II, fig. 4; Pl. III, fig. 1) originate from the lower side of the head, just in front of the anterior lip, and are generally extended downwards. They are rather short, scarcely exceeding half the length of the head, and are each composed of a short basal part and a somewhat narrower terminal part, the anterior edge of which is divided into 6—8 irregular rounded lobules densely set with small olfactory papillæ.

The antennæ, or oars (Pl. III, fig. 2) issue with a broad base from the sides of the head in front of the mandibles, and consist each of a thick, cylindric scape, and two slender, multiarticulate rami. The outer part of the scape is divided into numerous short articulations, the greater part of which are clothed anteriorly with dense transverse rows of strong spiniform bristles. The rami are nearly twice as long as the scape, and are each divided into about 9 somewhat lamellar articulations provided posteriorly with a number of slender, densely ciliated natatory setæ, anteriorly with short spines. The number of setæ and spines somewhat varies in the different articulations, being on the whole greater on the distal than on the proximal articulations.

The anterior lip (Pl. II, figs. 5, 6; Pl. III, fig. 1) extends posteriorly as an immediate continuation of the ventral surface of the head, being only defined at the base by a very slight depression. It has a convex lower face and a concave upper one, and terminates in a very delicate tentacular process, finely ciliated in its outer part. Seen from below (Pl. II, fig. 5), it appears rather broad in its proximal part, exhibiting at the base of the terminal process on each side a distinctly projecting corner. Between these corners issues from the upper face (see fig. 6) an oval, vertical lamella, which applies itself between the maxillæ, when the lip is bent in against the oral area. Within the body of the lip several glandular bodies may easily be traced, as also a number of transverse muscular bands apparently acting upon the soft upper part of the lip, and thus assisting in the process of swallowing.

The mandibles (see Pl. III, fig. 1) appear as a pair of much bent bows extending on the sides of the head at its junction with the cervical segment, and meeting below at the oral aperture. On a closer examination (see Pl. II, fig. 7), the masticatory part is found to be defined from the upper navicular part of the mandible by a distinct neck-shaped constriction and is strongly incurved, terminating with a finely fluted, triturating surface (fig. 8).

The anterior maxillæ (Pl. II, fig. 9) exhibit the usual structure, being each composed of a thick, muscular basal part and a thin semilunar lamella movably articulated to its end, and fringed with a dense row of incurved, falciform setæ.

The posterior maxillæ (fig. 10) are very small and rudimentary, forming only 2 simple conical prominences lying somewhat outside the anterior maxillæ, and each tipped with 2 very small hairs.

Of branchial legs there are 20 pairs present, the posterior of which, however, are so very small as easily to escape attention. In the two Japanese species, Mr. Ishikawa states the number to be only 18 pairs, and the same number is also given by Dr. Packard in the 2 American species, it being regarded by him as a generic character. In the North Australian species, however, there is quite certainly a greater number of legs, and by repeated dissections, I have constantly found in fully grown specimens 20 pairs, as above stated. In structure, the legs would seem to agree exactly with those in the other species of the genus, the epipodites being of very large size, as compared with those in *Limnadia* and *Paralimnadia*. On a closer examination, they are found successively to increase in size from the 1st to the 7th or 8th pair, where they attain their fullest development; from thence, they again rapidly diminish in size backwards (see Pl. II, fig. 3; compare also Pl. V, fig. 8). The endopodite (see Pl. III, figs. 4, 5) exhibits the characteristic narrow form, and has at the base a well-developed, incurved coxal lobe, terminating in 2 short denticles, and having inside, an obliquely transversal row of falciform delicate setæ, outside, a longitudinal row of much coarser plumose bristles (see fig. 6). The 5 endites are all well defined, the 3 upper ones being, however, but slightly prominent, whereas the 4th, especially on the anterior pairs (figs. 4, 5), is strongly produced, forming a linguiform lobe reaching almost to the tip of the 5th endite. The latter is movably articulated to the end of the stem, and has the form of a narrow oblong blade edged outside with long plumous setæ. On each of the preceding endites there is a double series of more or less strongly curved, thin, biarticulate setæ. The exopodite is divided into a dorsal and a ventral lappet, the latter being the larger, though in the anterior pairs not extending quite to the tip of the endopodite. The dorsal lappet in the 1st pair (fig. 4) is very small, whereas in the succeeding pairs it is much more developed, though not extending nearly to the tip of the exopodite. Fig. 1 on Pl. IV represents a leg of the 8th pair, showing the great development of the epipodite, which is more than twice as long as the dorsal lappet of the exopodite, and terminates in an acute point. In this pair, as also in those immediately preceding and succeeding it, the ventral lappet of the exopodite extends considerably beyond the end of the endopodite, whereas the 4th endite of the latter has become considerably shorter than in the anterior pairs. In the 9th and 10th pairs (see Pl. II, fig. 2; Pl. IV, fig. 2) the dorsal lappet of the exopodite is prolonged to a slender thread-like lash, tapering to a fine point (fig. 2 a), and extending upwards into the dorsal cavity of the shell, where it serves for keeping in place the egg-mass there accumulated. Fig. 3 on Pl. IV represents a leg of the 15th pair magnified to the same scale as the previously described legs. As shown by the figure, this leg, though scarcely half as large as the anterior ones, exhibits quite a normal structure. The hindmost pairs, on the other hand, successively assume a somewhat different appearance, owing to the considerable shortening of the endopodite, and the consequent dense crowding together of the endites. Fig. 4 represents a leg of the last (20th) pair magnified to the same scale as the preceding figures, and fig. 5, the same leg much more strongly magnified. It will be seen, that the coxal lobe is still rather well developed, whereas the endopodite itself is greatly reduced in size, being scarcely longer than the former, though still exhibiting all its endites. These are, however, very small and densely crowded together, for which reason their setæ are also much less numerous than on the other pairs, and of a somewhat different appearance, not being falciform. The exopodite is in the form of a rather broad plate extending downwards and considerably beyond the endopodite. The plate carries 9 strong, and rather distant, plumous setæ, the uppermost of which originates from a short conical process representing the rudimentary dorsal lappet of the exopodite. The epipodite is of inconsiderable size, and extends straight outwards, instead of, as in the greater number of the other legs, upwards.

Description of the male.

(Pl. V, VI).

The shell of the only specimen examined has a length of $5^1/_2$ mm., and is accordingly considerably smaller than that of the female, though the specimen appears to have attained its full size, exhibiting, as it does, the same number of lines of growth as in adult females.

In form (see Pl. V, figs. 1, 2), the shell looks exactly like that of the female, and has the dorsal margin curved in the very same manner, so as to be scarcely distinguishable from that of young female specimens. It is therefore only by examining the enclosed animal that the sex is to be ascertained.

Fig. 3 on the same plate represents, more highly magnified, the whole animal extracted from the shell, and viewed from the left side. As shown by the figure, the male character of the individual is at once revealed by the peculiar structure of the 2 anterior pairs of legs, which are both transformed into strong grasping organs. They also both exhibit a very strong curvature, and are extended somewhat apart from the other legs, being applied with their proximal part against the lower face of the anterior division of the body. On a closer examination, some other well-marked differences from the female may also be found to exist.

Thus, the rostral expansion of the head (fig. 4) is of a very different appearance, being produced to a rather prominent, triangularly pointed projection.

The antennulæ (ibid. and fig. 5) are much more fully developed than in the female, equalling the head in length. In the specimen examined, they were extended straight behind between the bases of the 2 anterior pairs of legs, whereas in the female they are, as a rule, found pointing downwards. As, however, these limbs are to a certain extent movable, their direction may, in the living animal, admit of being changed. The lobules of the terminal part appear much more sharply defined than in the female, and are very densely clothed with olfactory papillæ (see fig. 6). They are about 9 in number, and between them, faint transverse lines may be traced crossing the stem, thus indicating a slight articulation of the antennulæ.

The oars and oral parts do not exhibit any essential differences from those parts in the female.

The 2 anterior pairs of legs (Pl. VI, figs. 1, 2, 5) are, on the other hand, as above stated, of a very different appearance. They are both very powerfully built, and constructed in essentially the same manner, both having their anterior face strongly curved. On the proximal division of these legs, can be distinguished the same parts as in the female, viz., inside at the base, a well-developed coxal lobe, below which there are 2 or 3 rudimentary endites, outside, the vesicular, upwards-pointing epipodite and the exopodite, of which, however, only the dorsal and ventral lappets are distinct, whereas the median part is confluent with the stem. The distal division of the legs, which is connected to the proximal one by a rather movable articulation, is transformed into a rather complicated, sub-chelate hand of a somewhat quadrangular shape, having inside, about in the middle, a slight prominence (see figs. 4 and 6). At the end inside, the hand is produced to an obtuse, thumb-like projection, against which the strongly curved terminal claw admits of being impinged. To this projection is appended a small oval lamella extending towards the claw, and from the base of the latter another very delicate, subcylindric appendage is seen to issue, extending downwards. Of these parts, the claw would seem to represent the modified 5th endite, whereas the thumb may answer to the 4th endite in the female. The claw is articulated to the hand by a rather broad base, to the inner side of which a very strong muscle is seen to pass, with its fibres spread in a fan-like manner within the hand. It is suddenly bent inwards, with the outer part somewhat tumefied and armed, at the place where it comes in contact with the thumb, with a number of small tubercles (see fig. 7). From its tip issues a small, stalked sucking-disc, as in *Paralimnadia stanleyana.* The thumb is armed on the obtusely rounded tip with a dense crowd of incurved denticles, extending for some distance on its posterior face; and between them issue a number of stiff bristles curved inwards. The lamella appended to the thumb is likewise edged with bristles, which, however, are rather small and less densely crowded together. The sub-apical appendage issuing at the base of the claw, is generally extended in the axis of the leg, and consists of 2 joints the 1st of which carries at the end inside, a few small spines. The distal joint is of a very delicate structure, and somewhat claviform (see fig. 3), terminating in 2 unequal lobular expansions densely clothed with delicate papillæ of a similar kind to those found on the antennulæ. This appendage, which is undoubtedly of sensory significance, is, on the 1st pair of legs (figs. 1, 2, 4), about as long as the hand, whereas on the 2nd pair (figs. 5, 6) it is much more fully developed, being almost twice as long.

The 3rd pair of legs (fig. 8) only differ from those in the female in the fact of the 4th endite carrying on the tip a slender, cylindric appendage of a similar structure to that of the sub-apical appendage on the 2 anterior pairs, though here only composed of a single joint. Also on the 4th pair there is a slight rudiment of such an appendage (see fig. 9).

The succeeding pairs are of exactly the same appearance as in the female, except that the dorsal lappet of the exopodite in the 9th and 10th pairs is not prolonged in a thread-like manner, but is of the very same appearance as in the other legs.

The caudal part (see Pl. V, fig. 3) does not exhibit any essential difference from that in the female, either in form or armature.

Inner Organs.

Though I have not had an opportunity of examining the present Phyllopod in a living state, yet it has been possible to study rather well the chief inner organs in situ by rendering the body sufficiently pellucid in an artificial manner. This is best accomplished by transferring the body to oil of cloves, after it has been previously immerged in absolute alcohol, and very slightly stained with some colouring matter *(hæmatoxyline* or *carmine)* The body may then be examined, either at once, or after having been mounted in Canada balsam.

The intestine (see Pl. II, fig. 3; Pl. V, fig. 3) forms a cylindric tube extending through the axis of the body, and terminating in the caudal part with a short muscular rectum, that opens out between the caudal claws. Its anterior part, in the region of the adductor muscle of the shell, is suddenly bent downwards, and, immediately in front of the mandibles, joins the short æsophagus, which passes straight forwards from the oral orifice. Within the head, a complicated secretory apparatus is contained, appended to the foremost part of the intestine. This apparatus (see Pl. III, fig. 1; Pl. V, fig. 4), which is generally regarded as a kind of liver, consists of 2 symmetrical halves, each debouching by a short duct into the intestine somewhat laterally. The greater part of the organ occurs in the

Trykt den 9de Oktober 1896.

dorsal part of the head, forming there a large rounded mass, obtecting as a cap the foremost part of the intestine, and consisting of numerous irregular, twisted cæca. Inferiorly, a distinct lateral branch is sent off from each organ, extending to the ventral surface of the head in front of the anterior lip, where it subdivides into a number of rounded lobules. This apparatus is also constructed in essentially the same manner in the European *Limnadia lenticularis*.

The heart (see Pl. II, fig. 3; Pl. V, fig. 3) likewise agrees rather closely in structure with that in the above-mentioned Phyllopod, forming a comparatively short tube confined to the foremost part of the trunk, and extending within the hind part of the cervical segment. It is somewhat wider in front than behind, and exhibits 4 pairs of distinct venous ostia.

Of the nervous system, the part occurring within the head is not difficult to observe (see Pl. III, fig. 1; Pl. V, fig. 4). The supra-æsophageal, or cephalic ganglion appears, in a lateral view of the animal, as an opaque, somewhat quadrangular body lying immediately behind the ocellus. It is composed of 2 symmetrical halves confluent in the middle, and sends off in front 2 juxtaposed, very strong and elongated nerve-stems, the optic nerves, which each expand at the end into a claviform optic ganglion. From this ganglion, numerous fine nerve-fibres are seen to originate, entering the eyes and joining the several visual elements. Inferiorly the cephalic ganglion is produced on each side to a conical prominence, from the tip of which issue the nerves for the antennulæ. Just behind these prominences the great æsophageal commissures are sent off, and from the anterior part of these commissures the strong nerves for the oars originate. The ventral ganglion chain can only be observed by dissection, and would seem to agree perfectly with that in *Limnadia,* consisting of 2 long, juxtaposed nerve-stems, which in each segment form a very slight ganglionic swelling, and are connected at that place by a double transversal commissure.

The ovaries (see Pl. II, fig. 3) may be faintly traced through the integuments as 2 somewhat irregularly twisted tubes extending throughout the trunk on the sides of the intestine, each sending off ventrally a short oviduct, which debouches at the base of the 11th pair of legs. By dissection parts of the ovary can be isolated and submitted to a closer examination (Pl. IV, fig. 6). It is then found that, as in *Limnadia,* the ova are developed within follicles springing from the surface of the ovarial tubes. Such egg-follicles occur on the same ovary in all stages of development from very small subcylindric lobules to rather large globular bodies. In all the follicles 4 cells are combined (see figs. 7, 8), of which only the distal one represents the true ovum, whereas the other 2 are so-called nutritive cells. The latter become at last wholly absorbed by the true egg-cell, which rapidly increases in size and becomes filled with an opaque granular yolk-mass. The ripe ova, when poured off from the ovarial tubes, are accumulated within the dorsal part of the shell-cavity, forming there an irregular mass (see Pl. II, fig. 1, 2). They are comparatively small and of a rounded form, each being provided with a rather firm shell or capsule. On a closer examination, this shell exhibits (see Pl. IV, fig. 10) a very uneven surface, being divided into depressed hexagonal facets, the angles of which protrude as pointed projections. When rendered pellucid by the aid of oil of cloves (fig. 9), each egg-capsule is seen to contain in the centre a comparatively small, perfectly globular body, surrounded by a very delicate pellucid membrane. This is the egg proper, which is accordingly of very small size, but little exceeding half the diameter of the egg-capsule itself.

The testes occupy the same place as the ovaries, and are also of a rather similar form. The follicles, however, (see Pl. V, fig. 7) are of a more uniform size, and as it were irregularly twisted. They each contain a cavity, which is in communication with the central hollow, and from their inner walls the spermatic elements are developed in the form of simple small cellular bodies. I have not been enabled by dissection to state at which places the vasa deferentia debouch; but in the specimen examined there was found (see Pl. V, fig. 3) externally, on each side of the body, just above the bases of the 9th, 10th and 11th pairs of legs, an opaque granular mass, which had much the appearance of being coagulated sperm, which might have been recently poured off from the body. This induces me to believe, that the sexual openings in the male occur at the very same places, where they are found in the female, viz., at the bases of the 11th pair of legs.

Occurrence.—Of this beautiful form a rather large number of specimens were collected by Mr. Knut Dahl on the 3rd November, 1894, from a shallow pool on Mount Showbridge, in the neighbourhood of Port Darwin, North Australia. By far the greater number of the specimens were of the female sex, indeed I only succeeded in detecting among them a single male specimen, the one here described. This would seem to indicate, that the present form may at times propagate in a parthenogenetical manner.

Explanation of the Plates.

Pl. I.

Streptocephalus Archeri, G. O. Sars.

Fig. 1, Adult, ovigerous female, drawn from life; dorsal view; magnified 18 diameters.
» 2. Same exhibited from left side.
» 3. Head with eyes, antennulæ and antennæ; front view.
» 4. Outer part of a leg of 1st pair; magnified 52 diameters.
» 5. Leg of 4th pair; magnified 52 diameters.
» 6. Leg of last (11th) pair; magnified 52 diameters.
» 7, 8, 9. Three different views of an ovum extracted from the marsupium.

Pl. II.

Eulimnadia Dahli, G. O. Sars.

Fig. 1. Adult, ovigerous female, seen from left side; magnified 14 diameters.

Fig. 2. Same, dorsal view.
» 3. Another specimen, in which the left valve has been removed, in order to show the animal more distinctly; lateral view; magnified 18 diameters.
» 4. Left antennula; magnified 48 diameters.
» 5. Anterior lip, seen from below; magnified 48 diameters.
» 6. Same, exhibited from left side.
» 7. Left mandible, seen from the anterior side; magnified 48 diameters.
» 8. Lower extremity of same, with the molar surface, more highly magnified.
» 9. (not numbered in the plate) Maxilla of 1st pair; magnified 48 diameters.
» 10. (do.) Maxilla of 2nd pair.

Pl. III.

Eulimnadia Dahli, G. O. Sars.
(continued).

Fig. 1. Head of female, with part of the cervical segment, viewed from left side (oars omitted); magnified 35 diameters.
» 2. Left oar; magnified 35 diameters.
» 3. Tail with the adjoining part of the trunk, seen from left side; magnified 35 diameters.
» 4. Leg of 1st pair; magnified 48 diameters.
» 5. Leg of 2nd pair; magnified 48 diameters.
» 6. Coxal lobe isolated; magnified 88 diameters.

Pl. IV.

Eulimnadia Dahli, G. O. Sars. (continued).

Fig. 1. Leg of 8th pair; magnified 48 diameters.
» 2. Leg of 10th pair; magnified 48 diameters.
» 2 a. Extremity of the thread-like upper lappet of the exopodite from same leg, more highly magnified.
» 3. Leg of 15th pair; magnified 48 diameters.
» 4. Leg of last (20th) pair; magnified 48 diameters
» 5. Same leg, magnified 170 diameters.
» 6. Part of an ovary, showing egg-follicles in different stages of development; magnified 155 diameters.
» 7, 8. Two egg-follicles isolated, somewhat more highly magnified.
» 9. An ovum, taken from the shell-cavity, and rendered pellucid, so as to show the central yolk-mass; magnified 88 diameters.
» 10. Another ovum, viewed as an opaque object; magnified 88 diameters.

Pl. V.

Eulimnadia Dahli, G. O. Sars. (continued).

Fig. 1. Adult male, viewed from left side; magnified 14 diameters,
» 2. Shell of same, seen from below, with the valves opened; magnified 14 diameters.
» 3. Animal, extracted from the shell, and viewed from left side; magnified 22 diameters.

» 4. Head, with adjoining part of the cervical segment, viewed from left side (oars omitted); magnified 35 diameters.

» 5. Left antennula; magnified 48 diameters.

» 6. One of the papilligerous lobules of same, more highly magnified.

» 7. Part of one of the testes; magnified 155 diameters.

Pl. VI.

Eulimnadia Dahli, G. O. Sars (male). (continued).

Fig. 1. Left leg of 1st pair, seen from the outer side; magnified 48 diameters.

» 2. Same leg, seen from the anterior face, and fully extended.

» 3. Distal joint of the sub-apical appendage from same leg; magnified 88 diameters.

» 4. Hand of same leg; magnified 56 diameters.

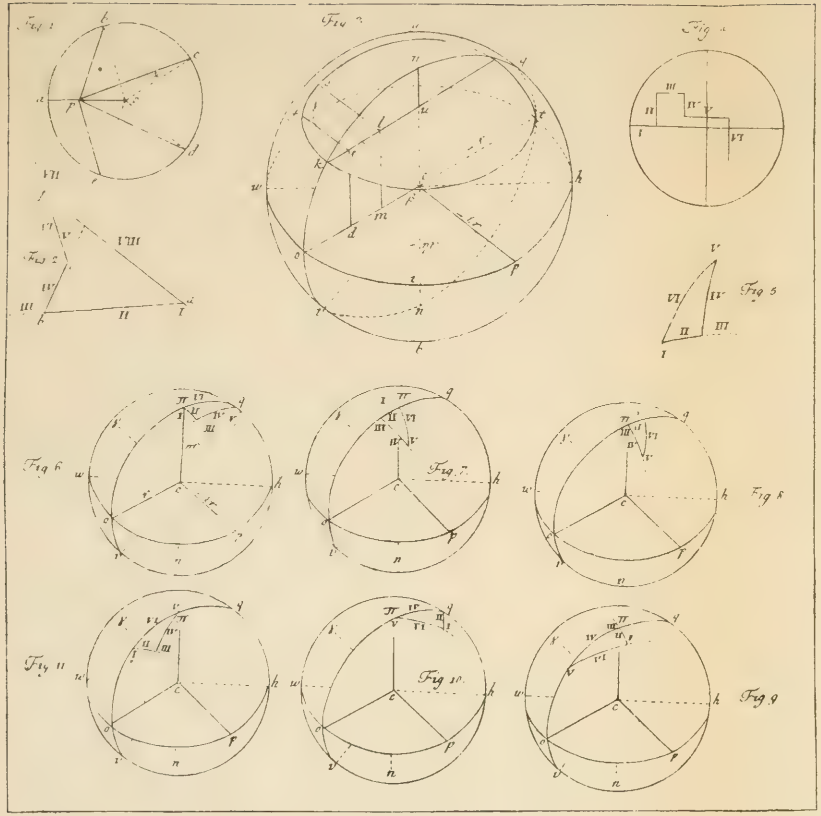
» 5. Left leg of 2nd pair, viewed from the outer side; magnified 48 diameters.

» 6. Hand of same leg; magnified 56 diameters.

» 7. Terminal claw, more highly magnified.

» 8. Leg of 3rd pair; magnified 48 diameters.

» 9. Outer part of a leg of 4th pair; magnified 48 diameters.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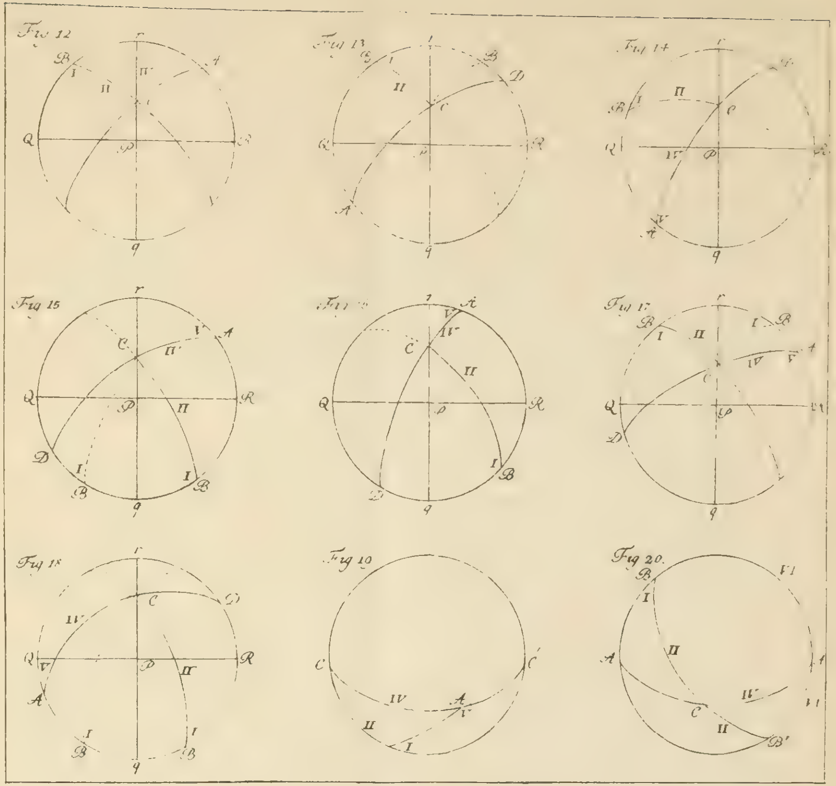
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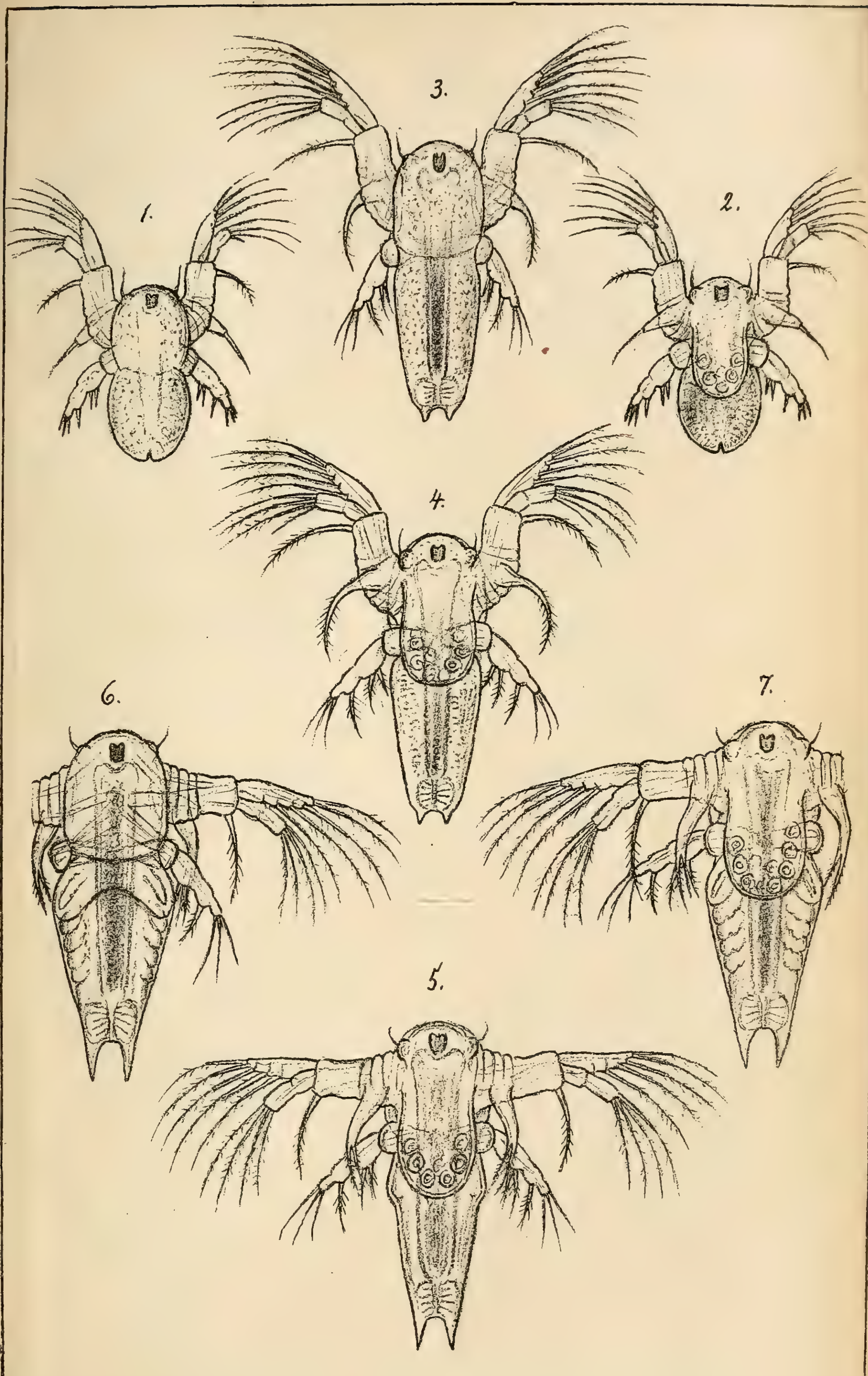

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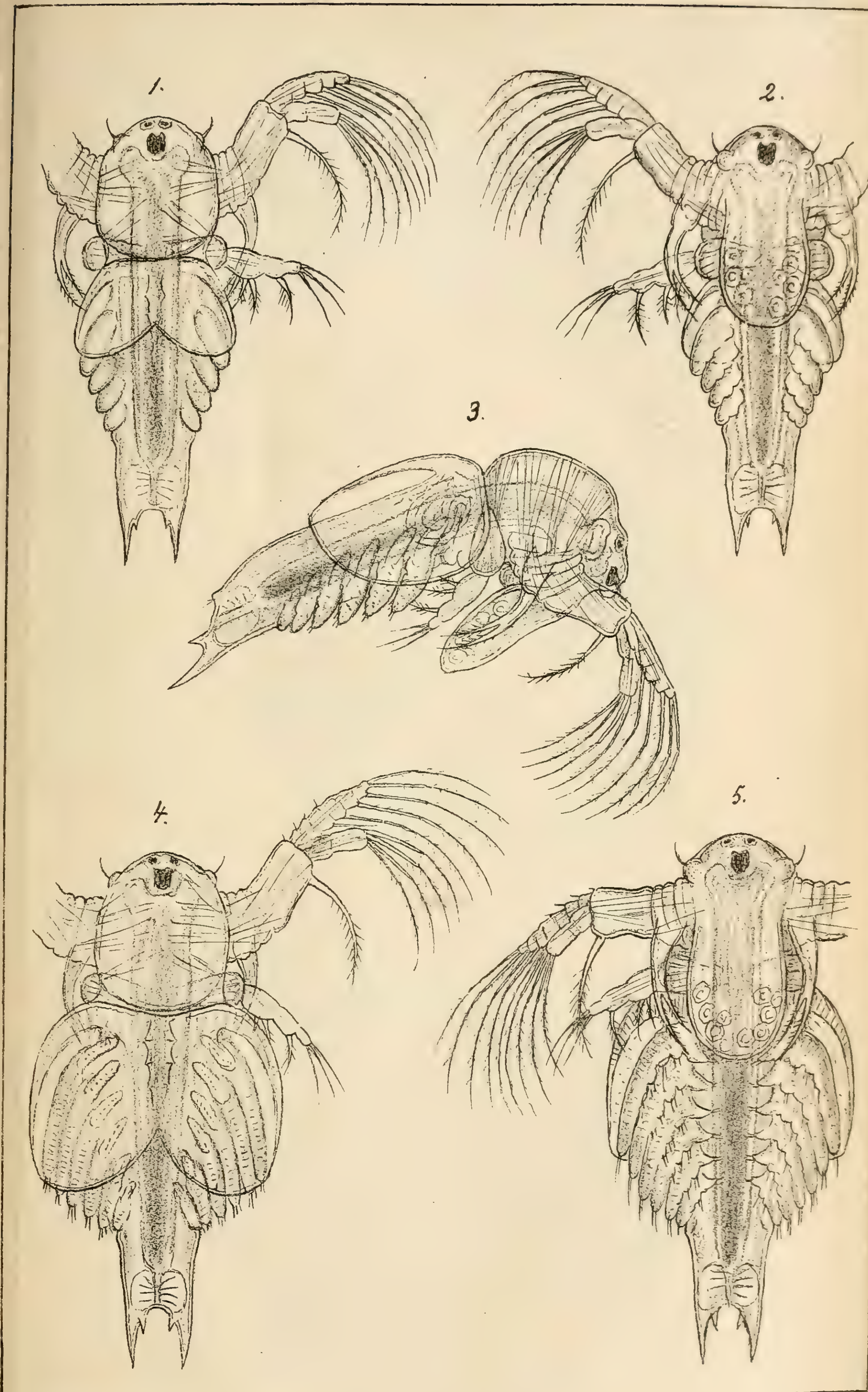

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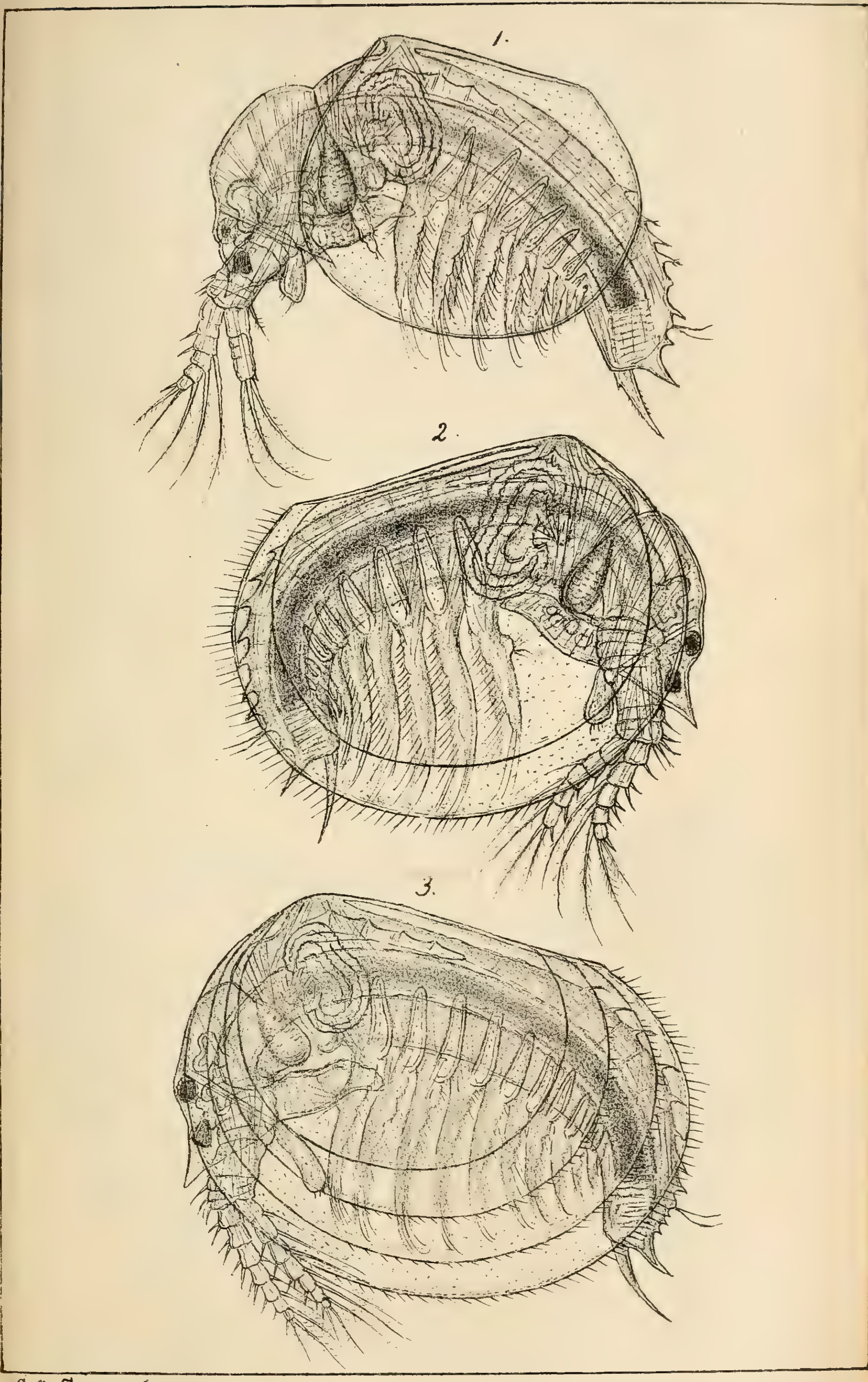

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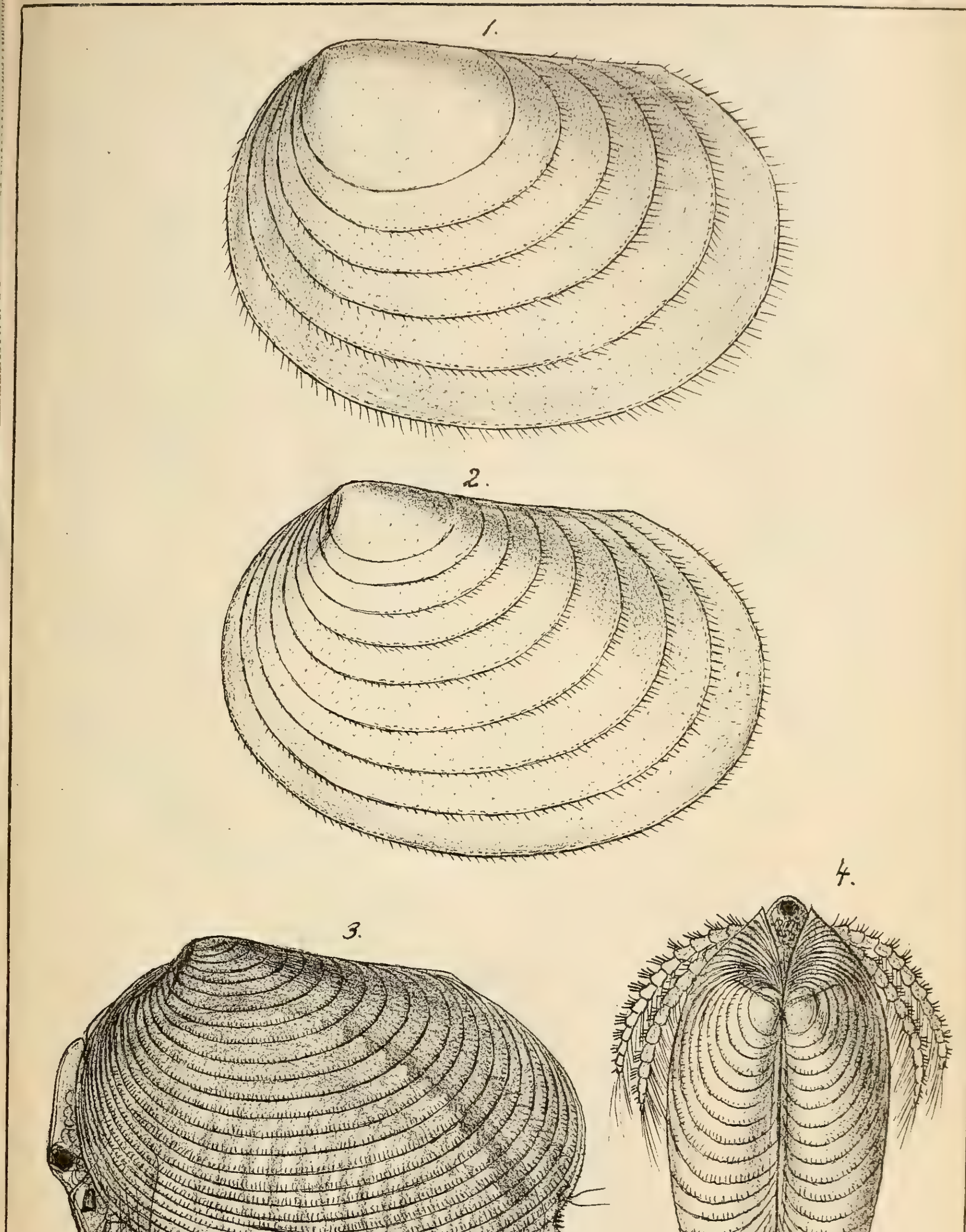

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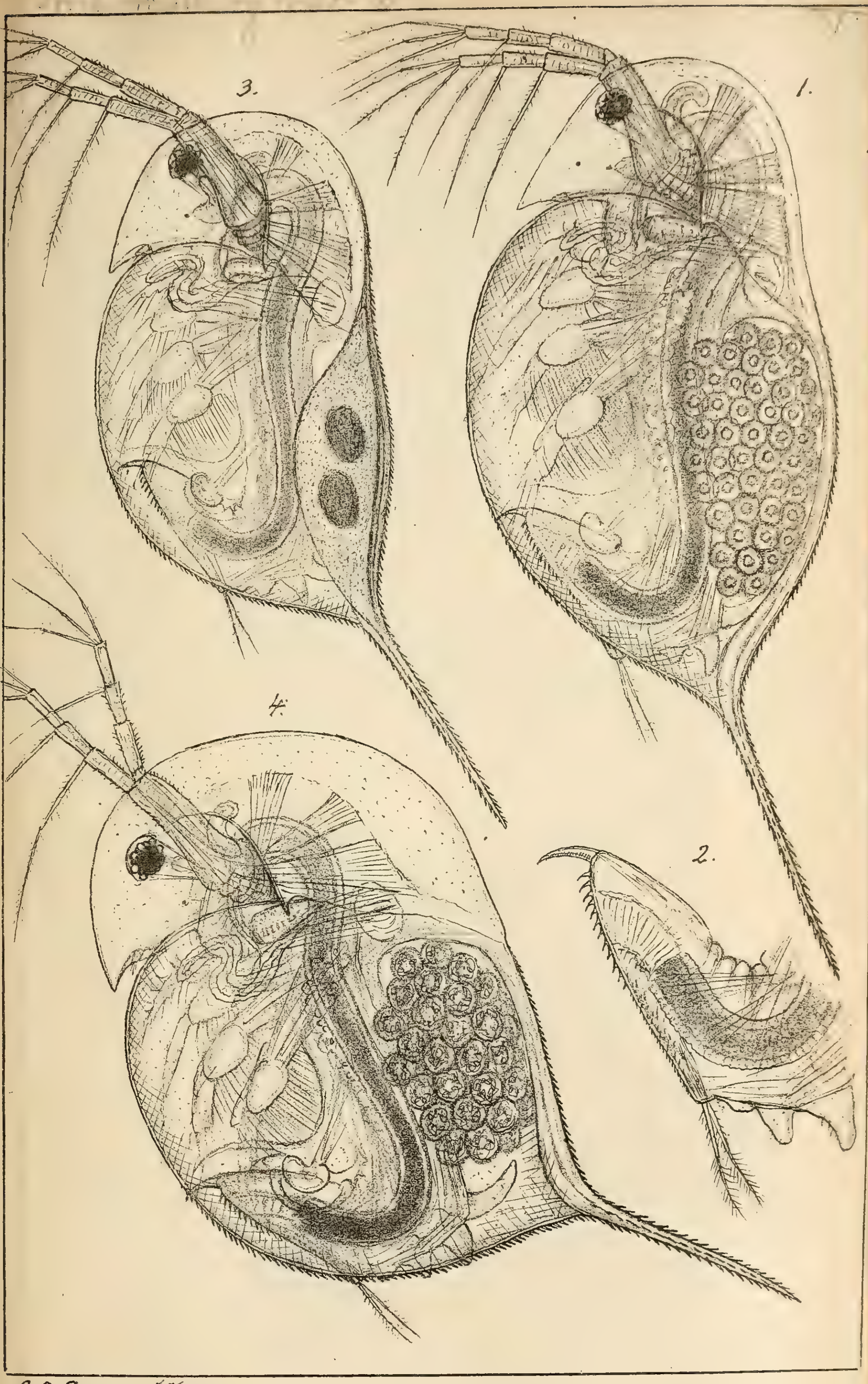

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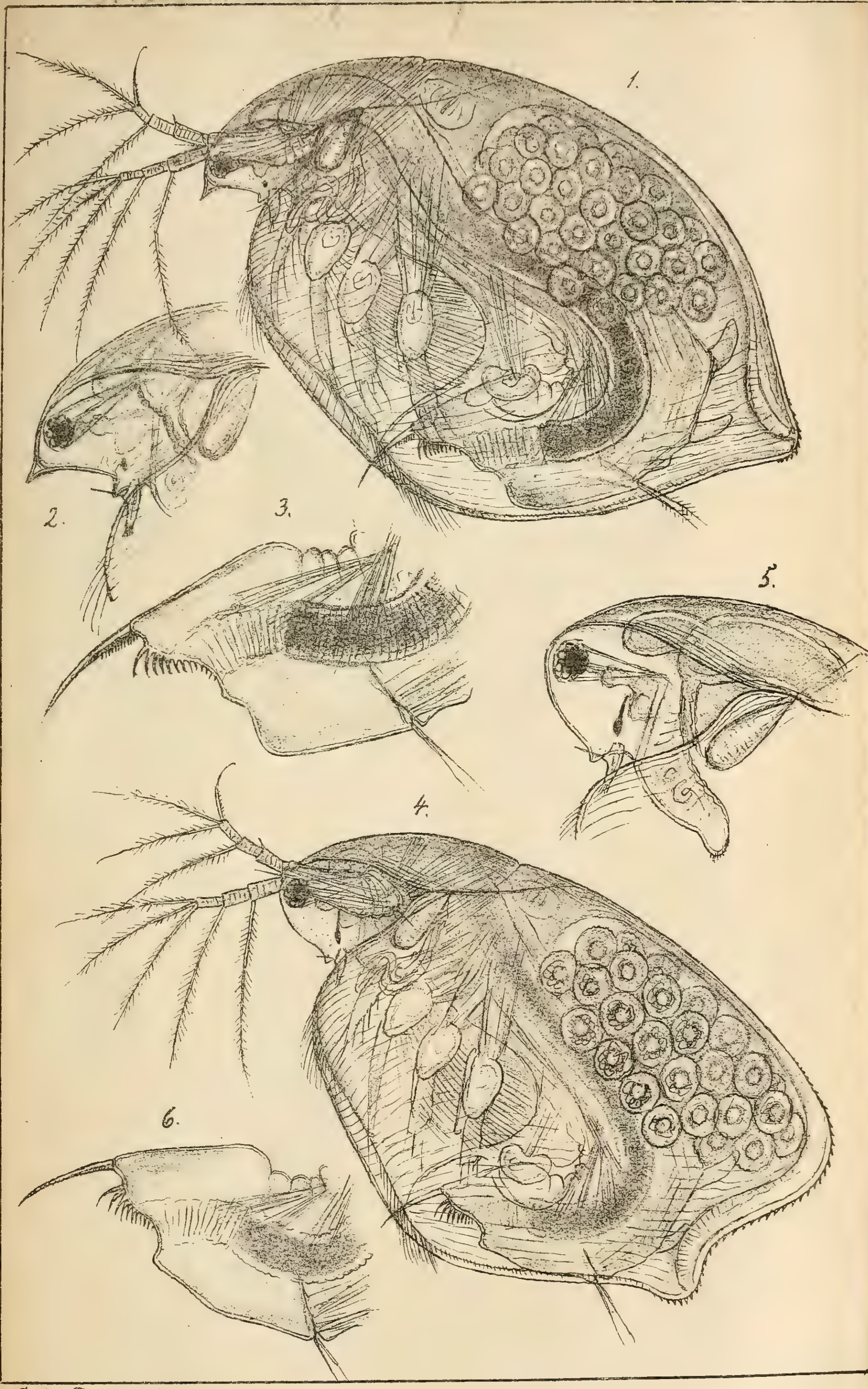

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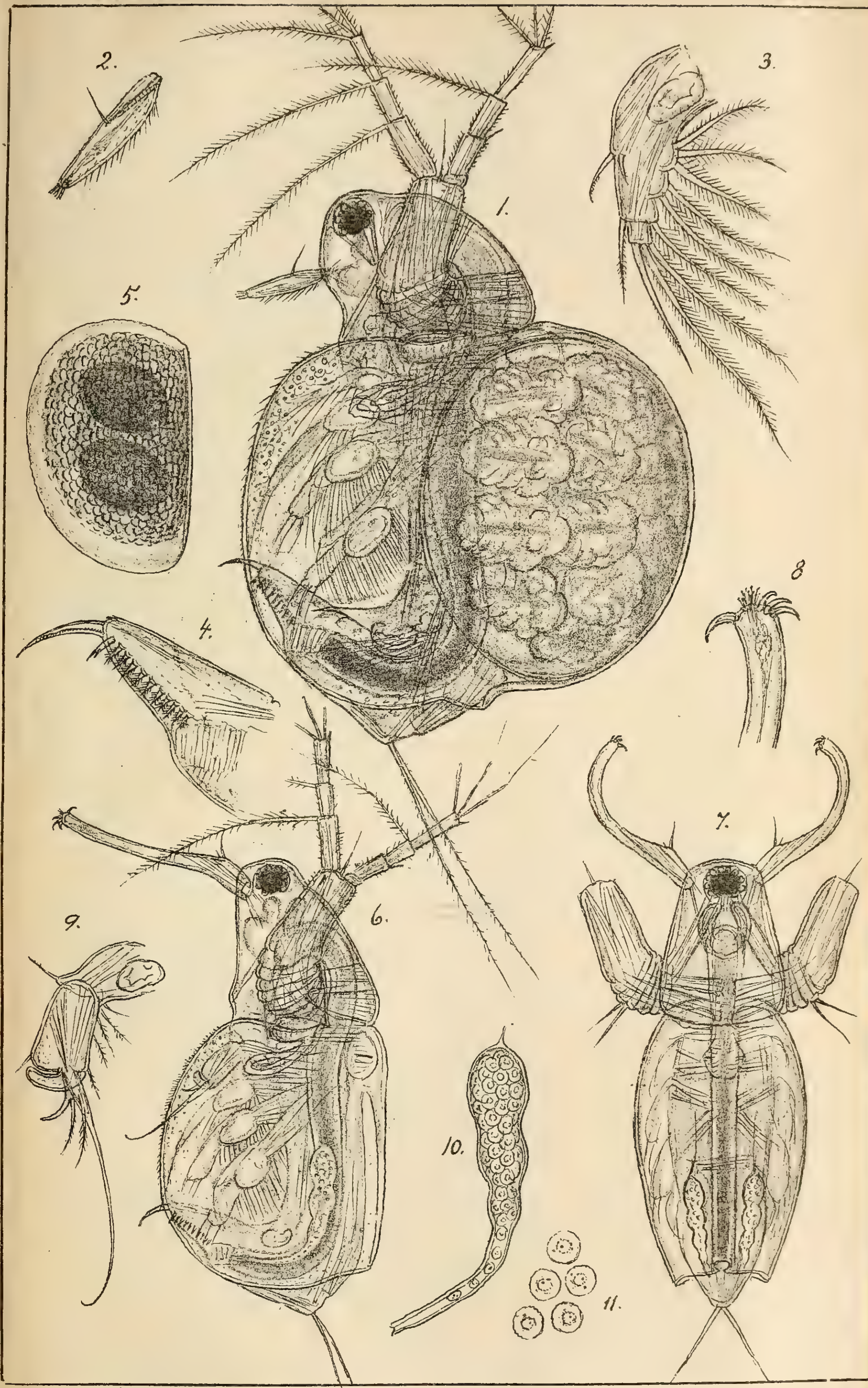

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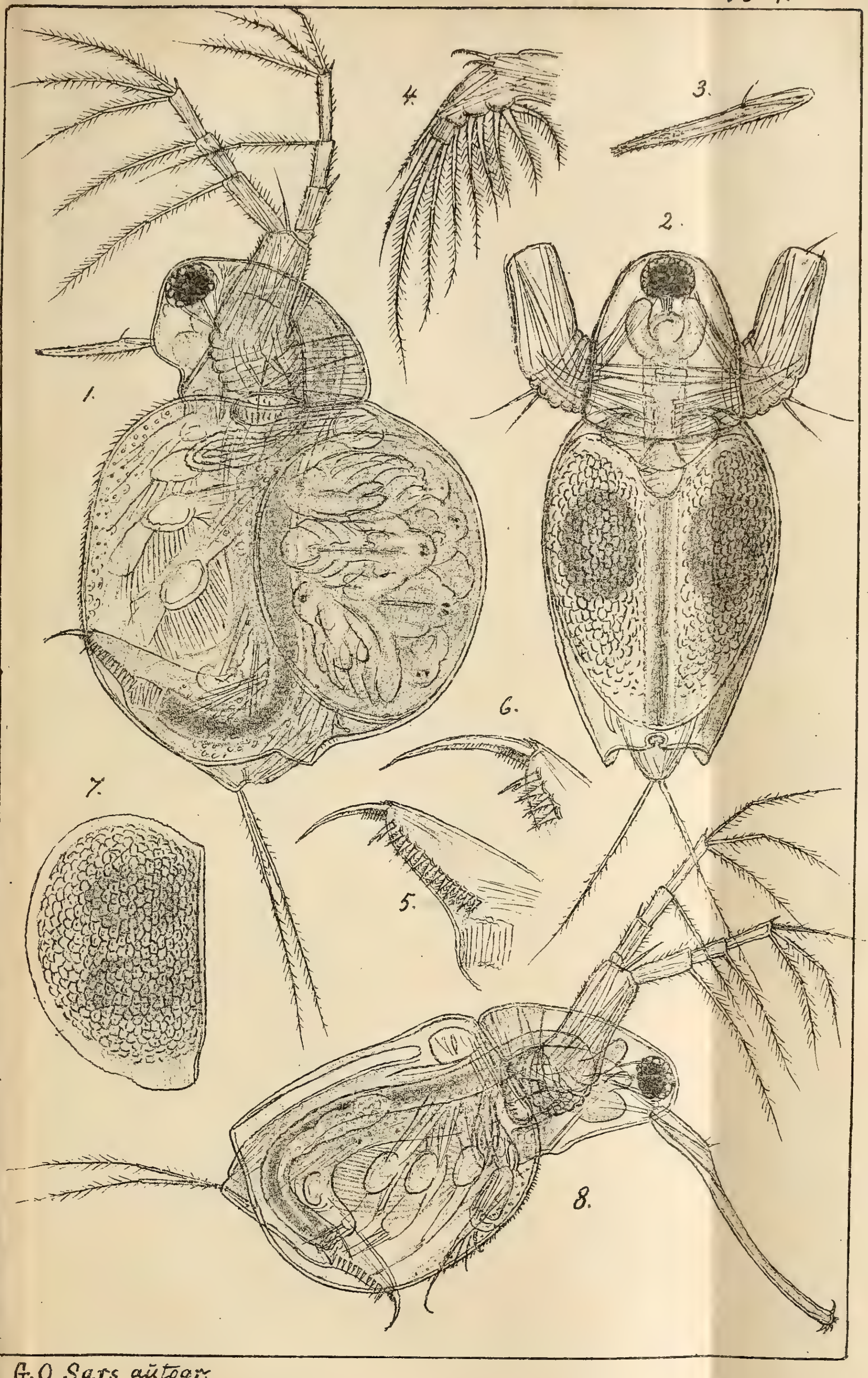

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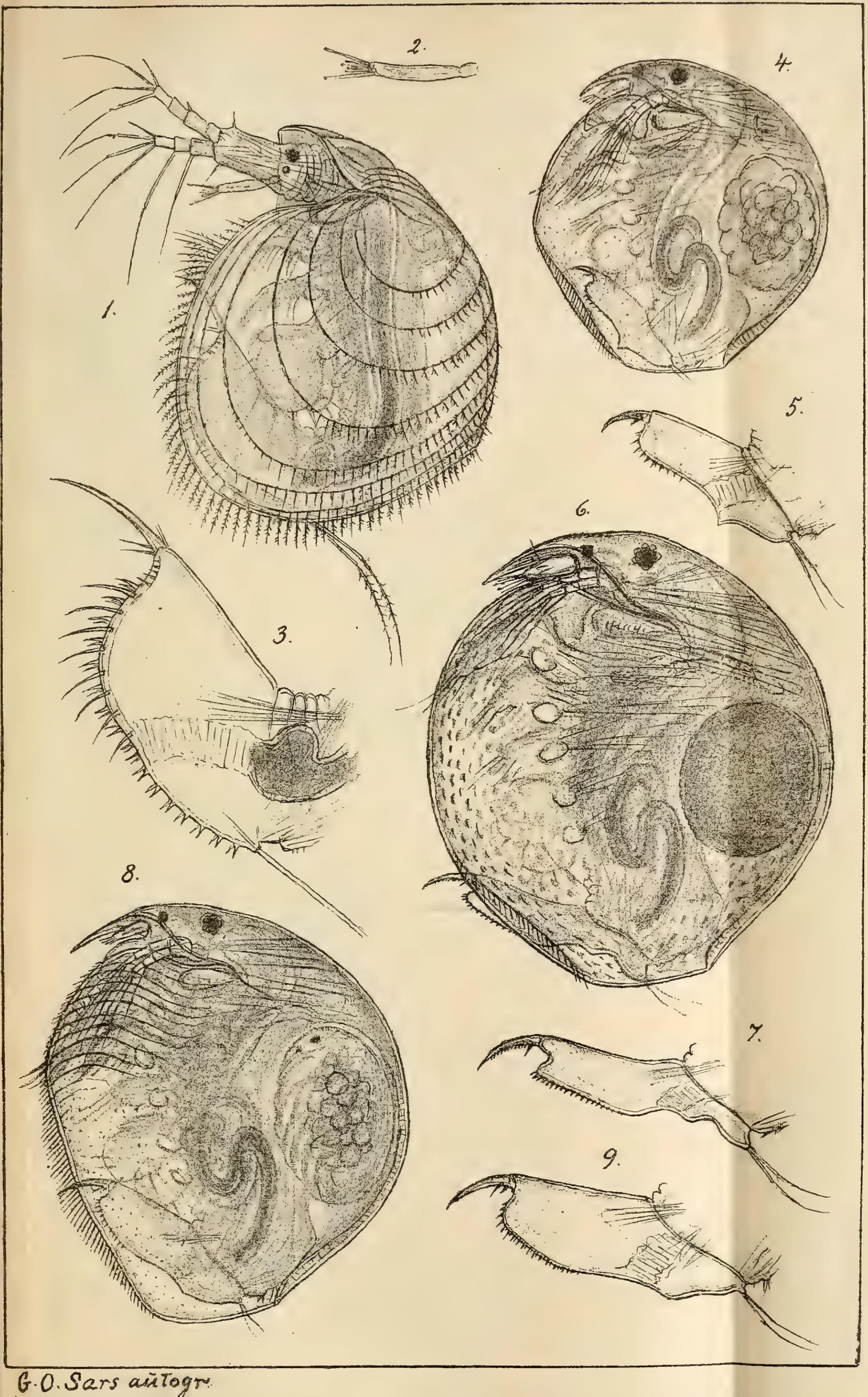

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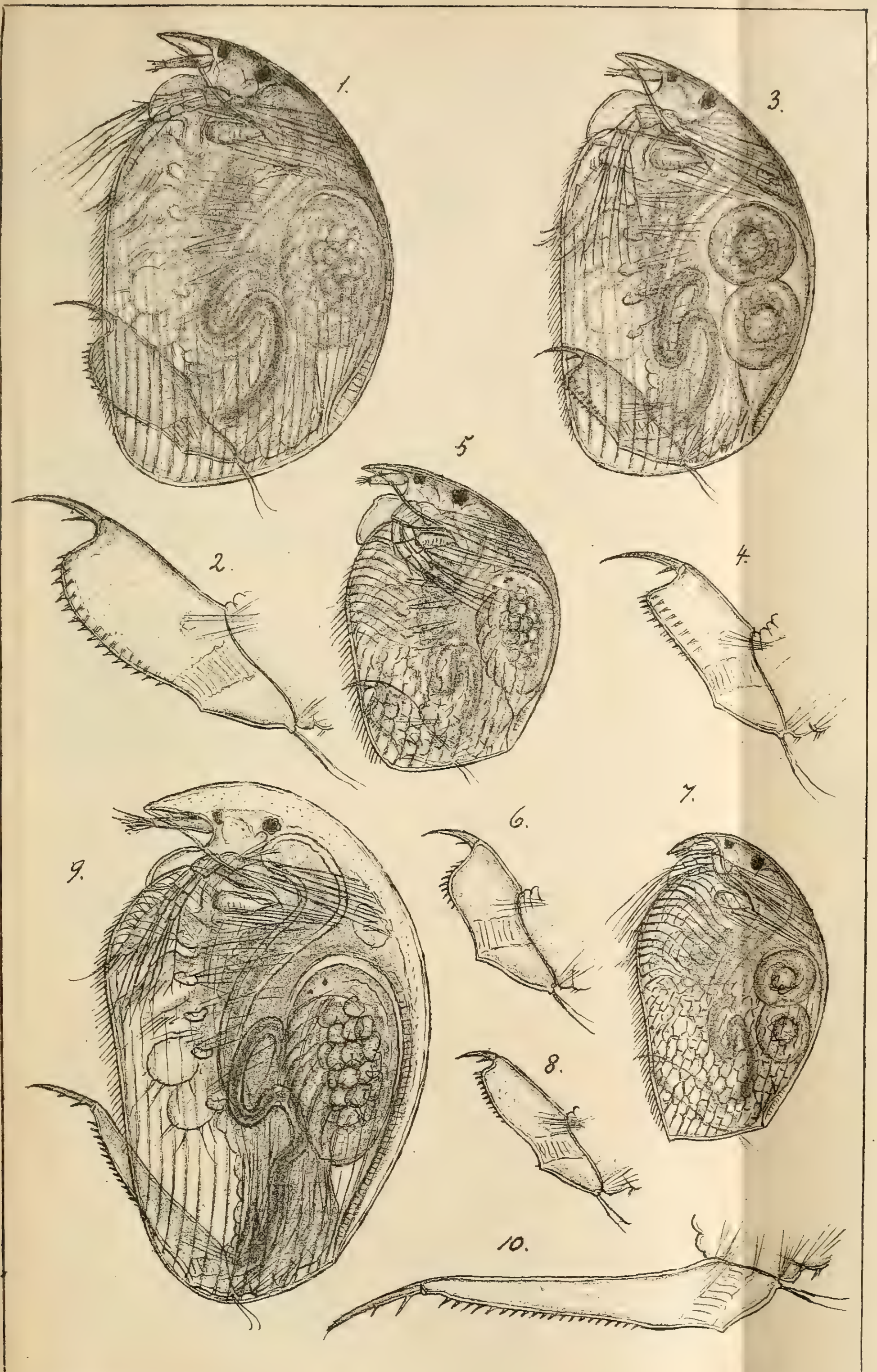

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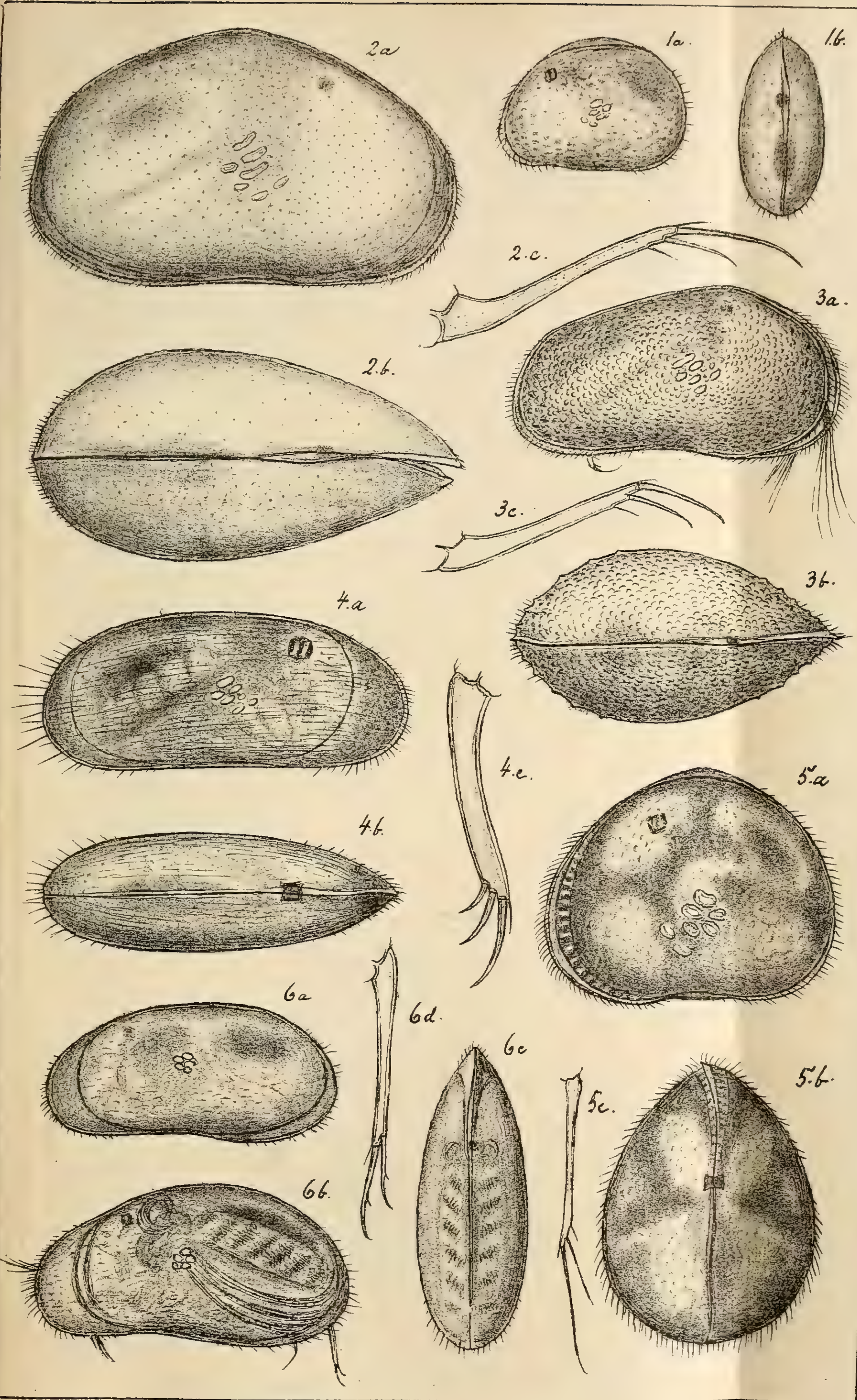

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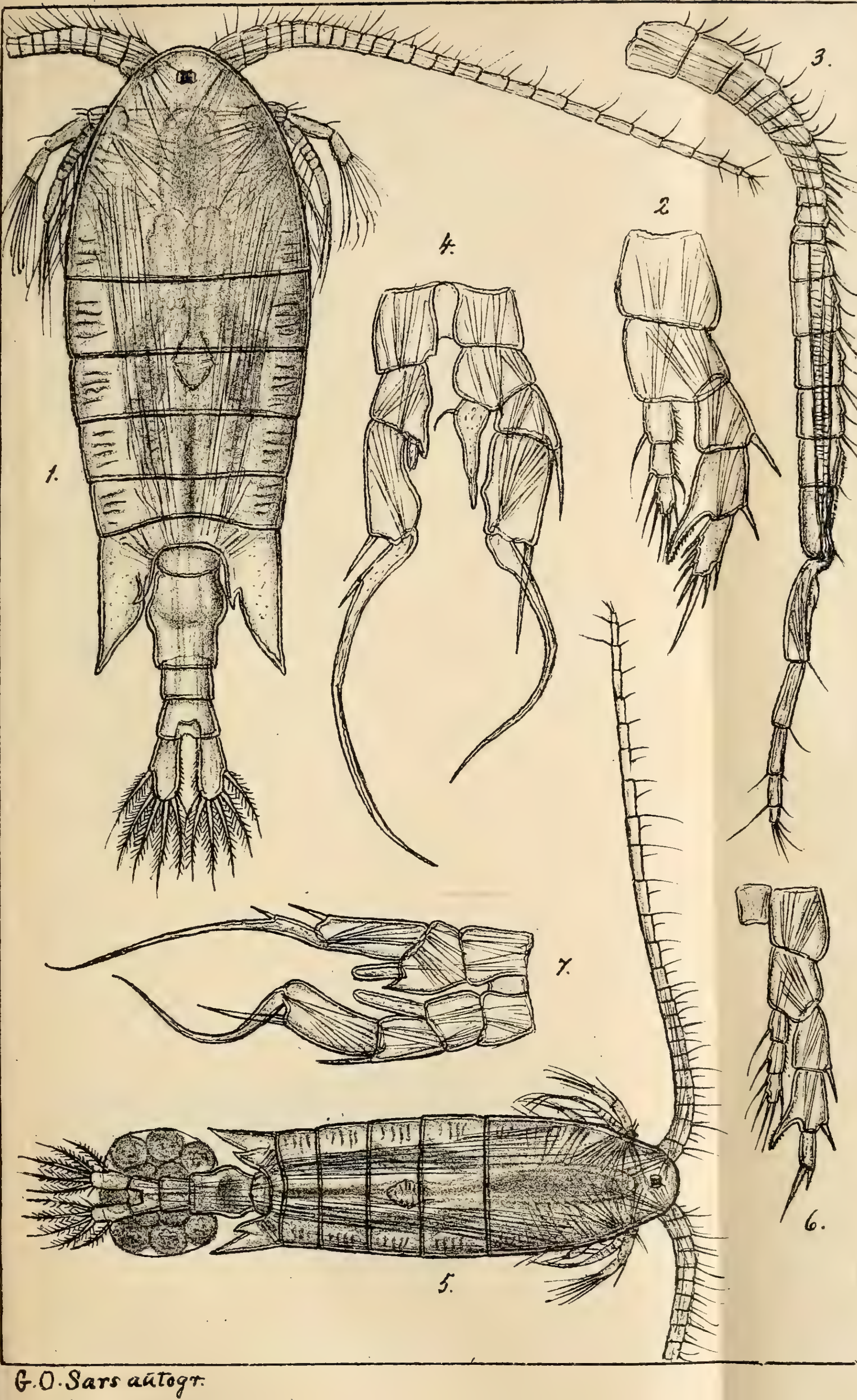


G. O. Sars autogr.

2° 0' Kr.

1° 40' ö. f. Kr.

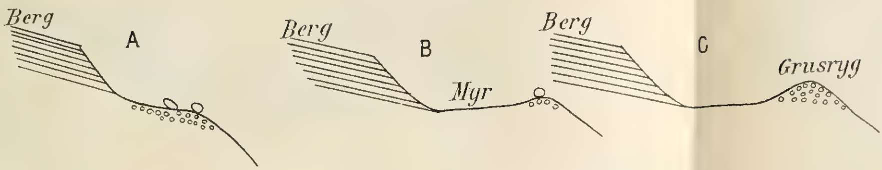
1° 20' ö. f. Kr.

Arch. f. m. og n. XVIII 6

Fot. 1.
Stendækket felt paa n. siden af moræneVolden ved Sandbovangen.

Fot. 2.
Terrasser op for Storeng i Dovre set fra Talleraas bro.
Ved øverste × 684 m. o. h. Længere tilvenstre 675 m. o. h. Ved nederste × 618 m. o. h.
Jettafjeld i baggrunden.

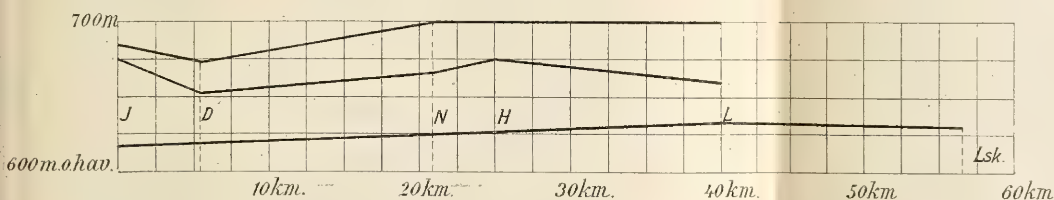
Fig. 3.



Profiler af terrassen ved Holaker i Lesja.

Fig. 4.

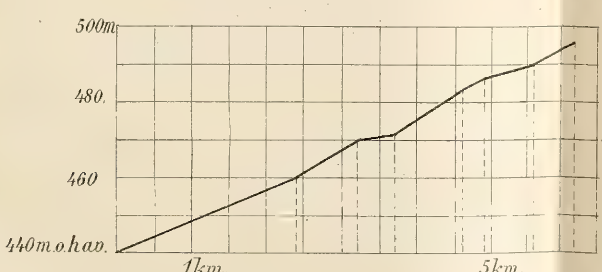
Grafisk fremstilling af de 3 terrasser i Gudbrandsdalen mellem Lesjeskogens vand og Jlka.



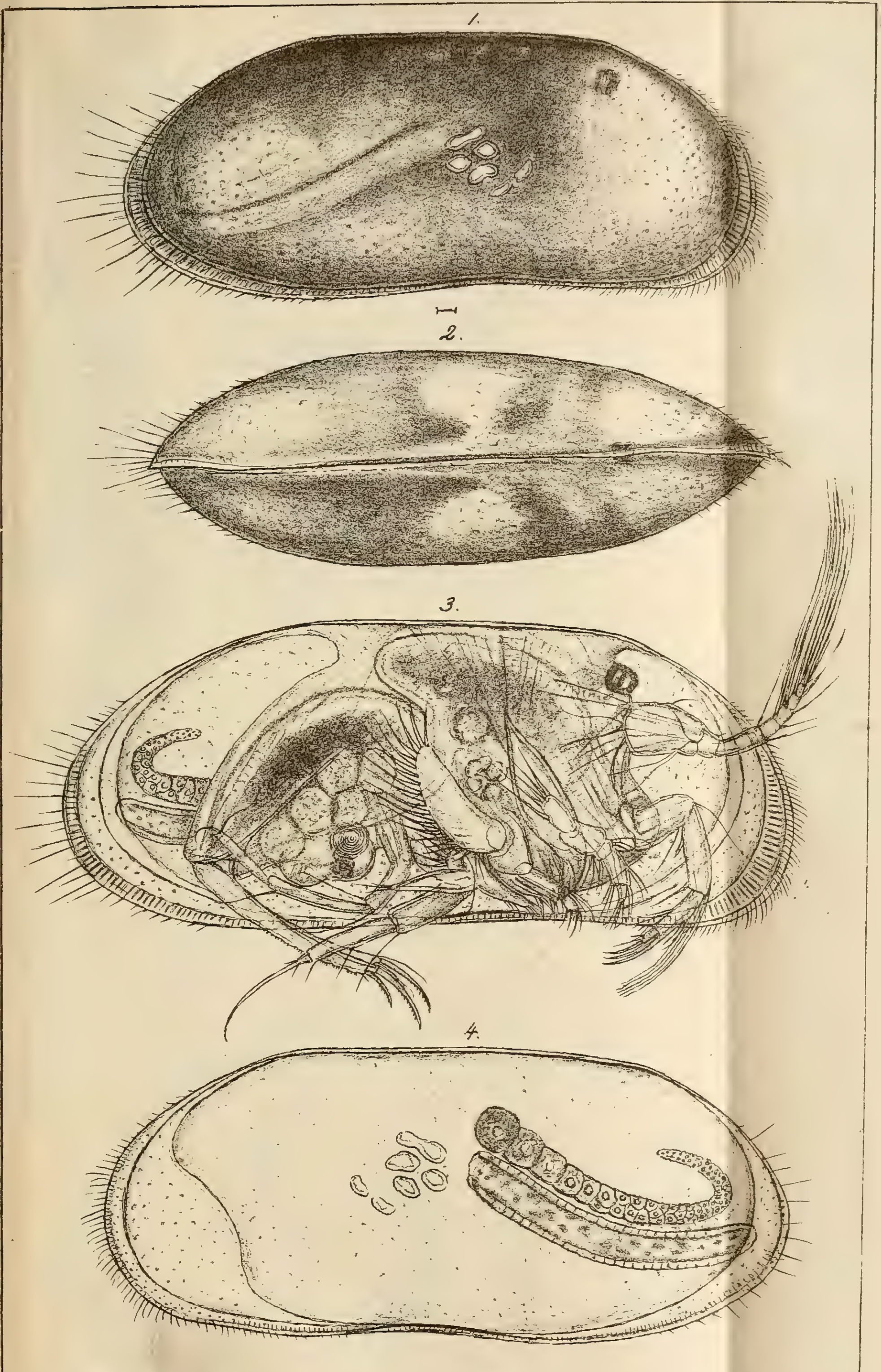
L=1 : 500000.
H=1 : 5000

Fig. 5.

Heldningen af terrassen i Hedalen mellem Ekre og Bjölstad.



L=1 : 100000.
H=1 : 2000.



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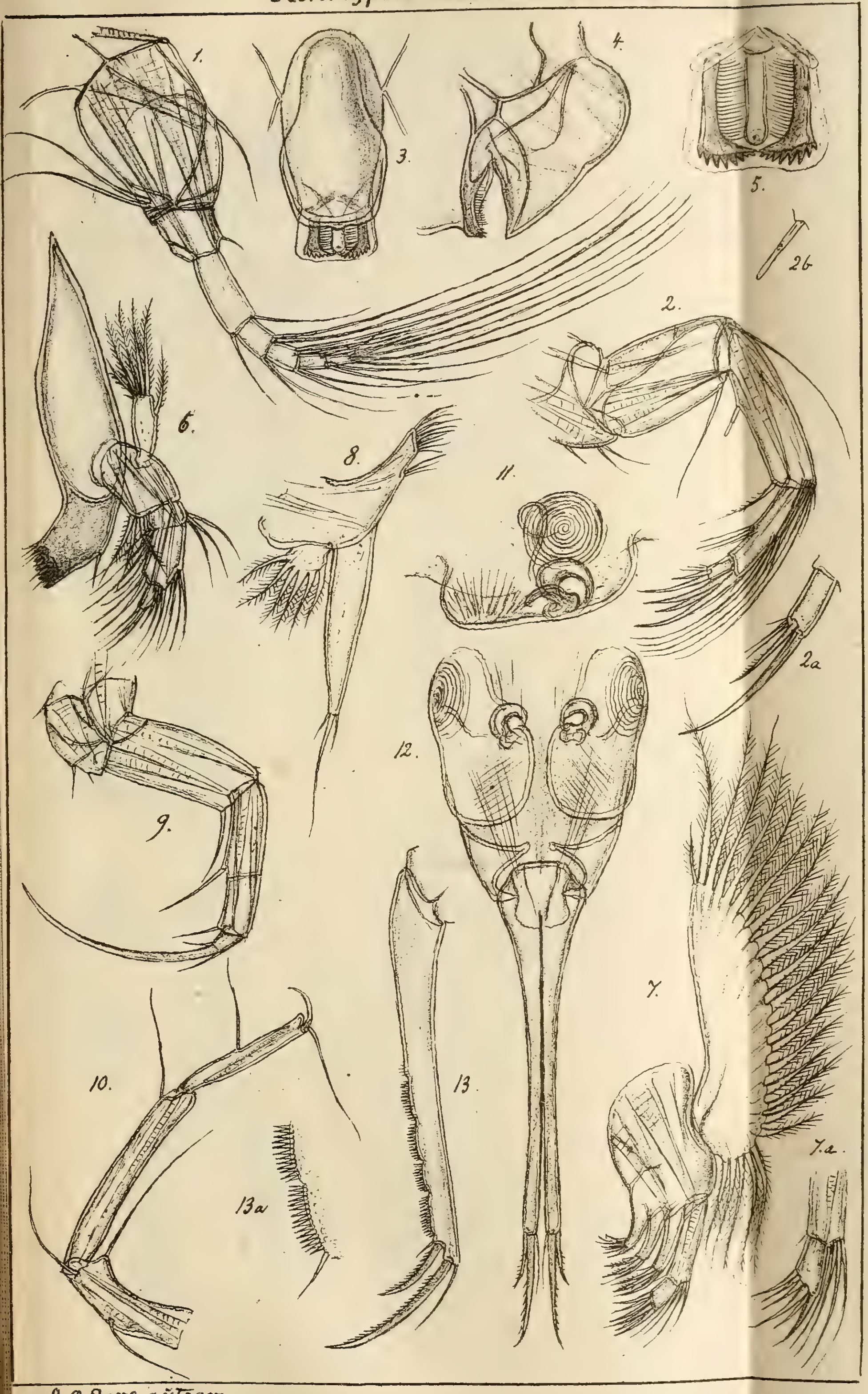

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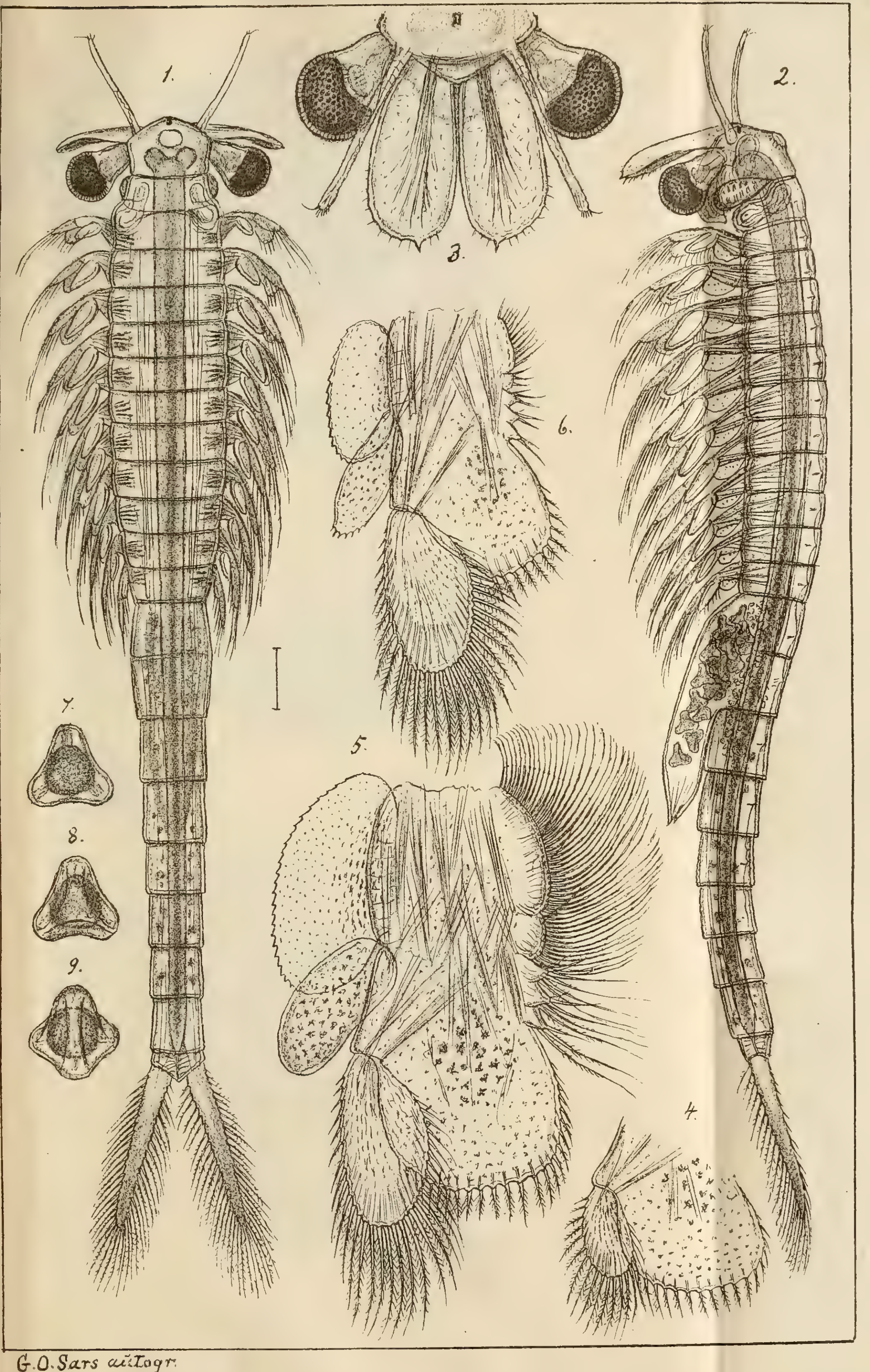

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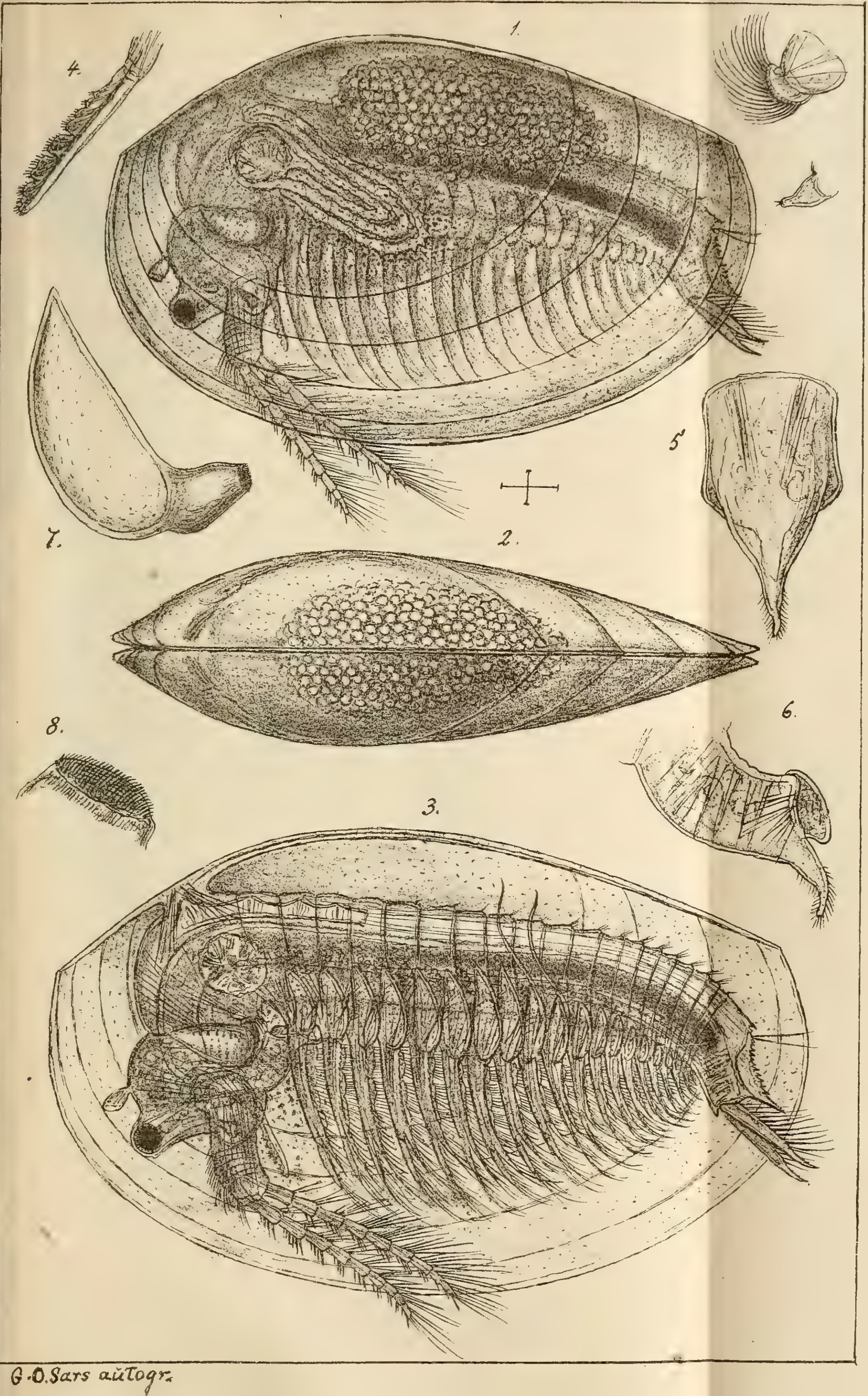

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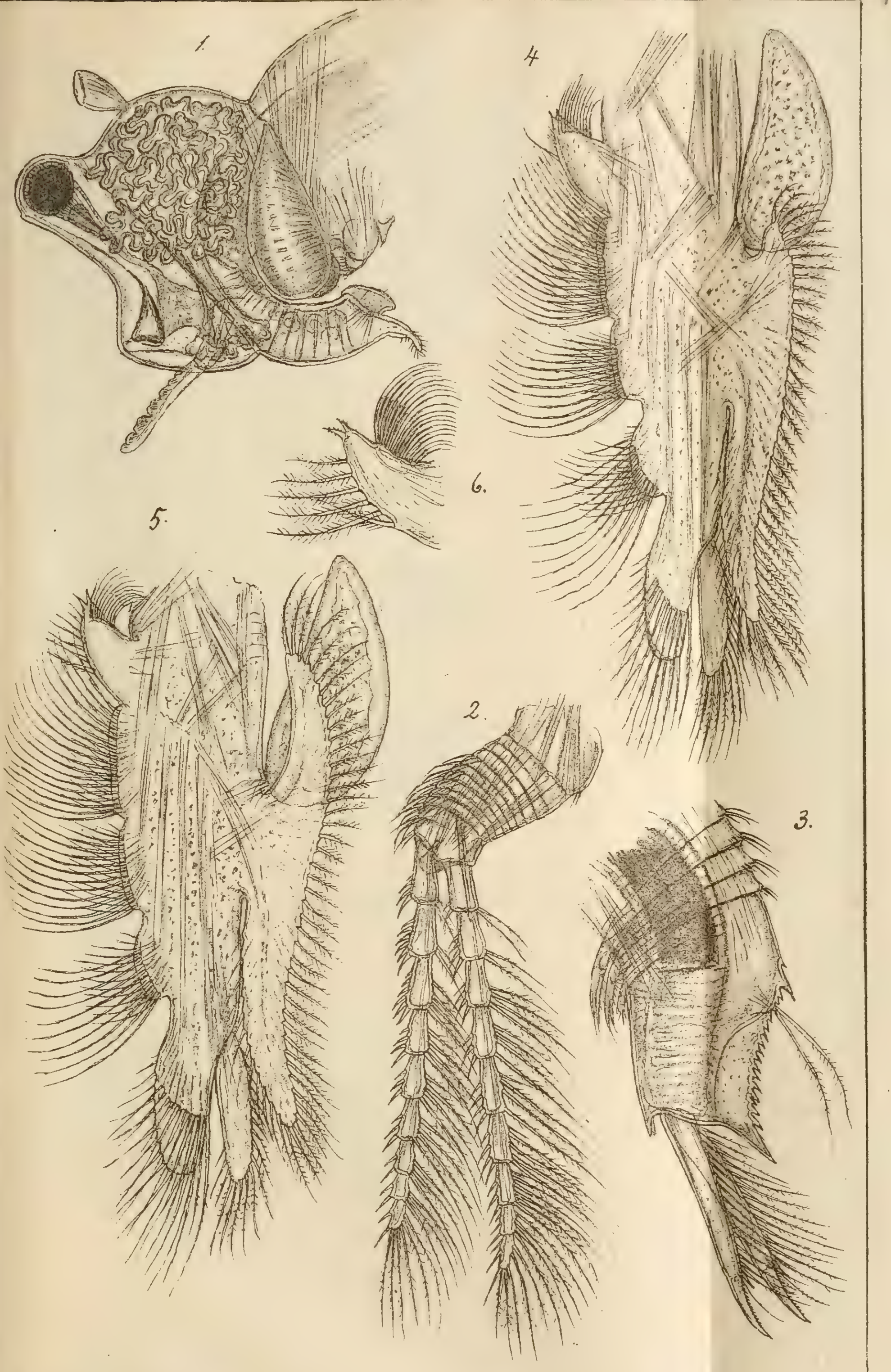

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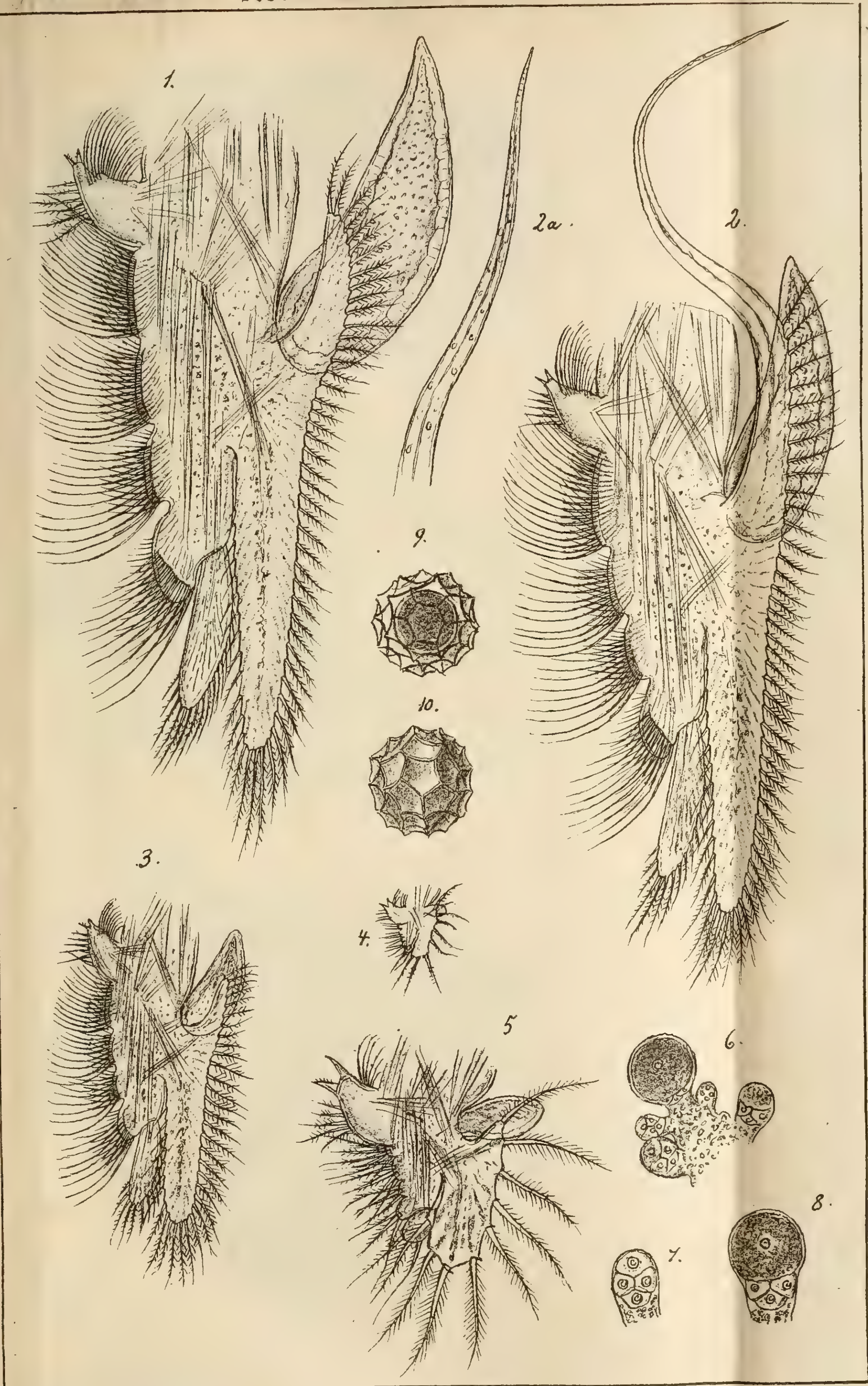

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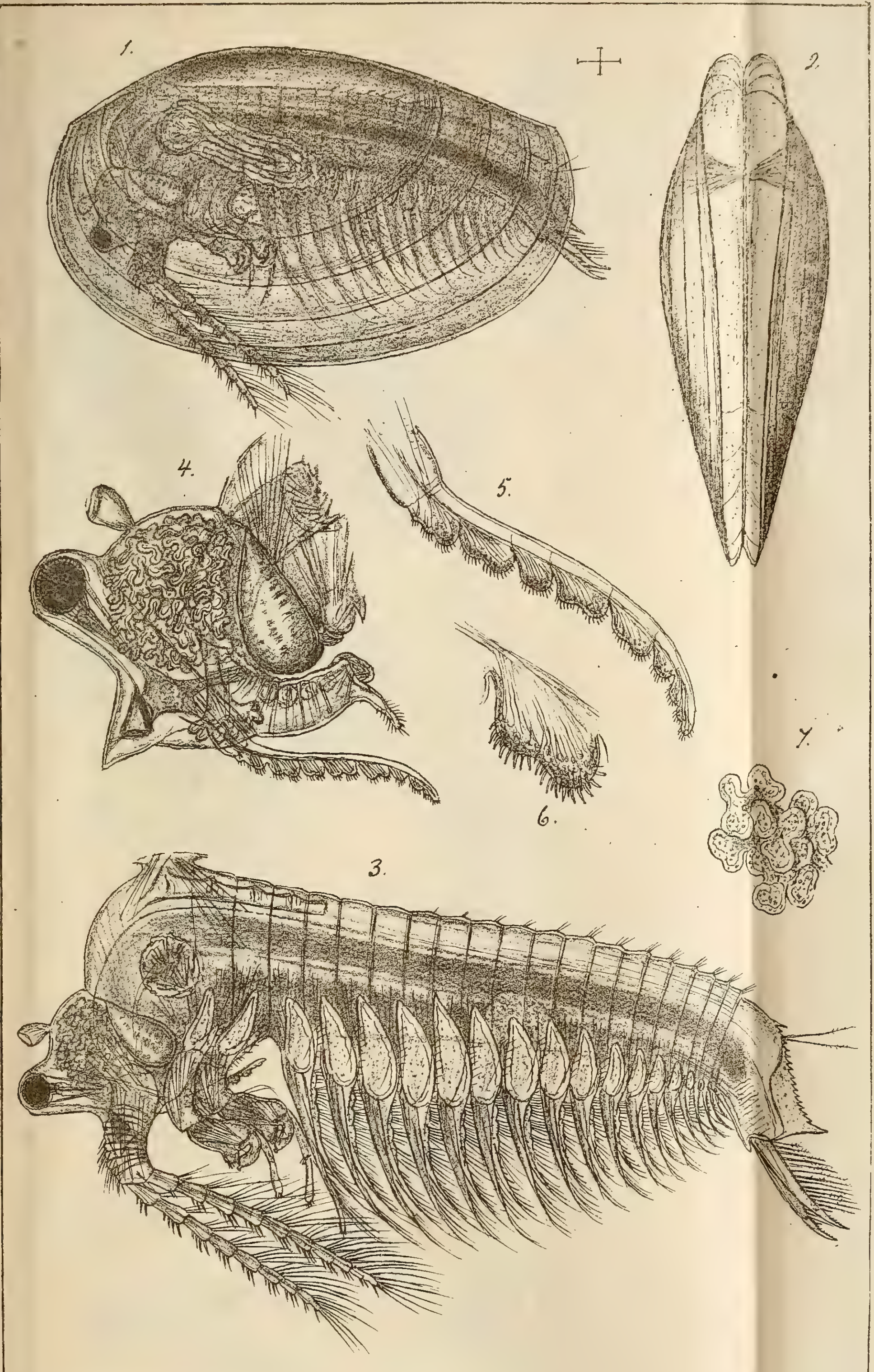

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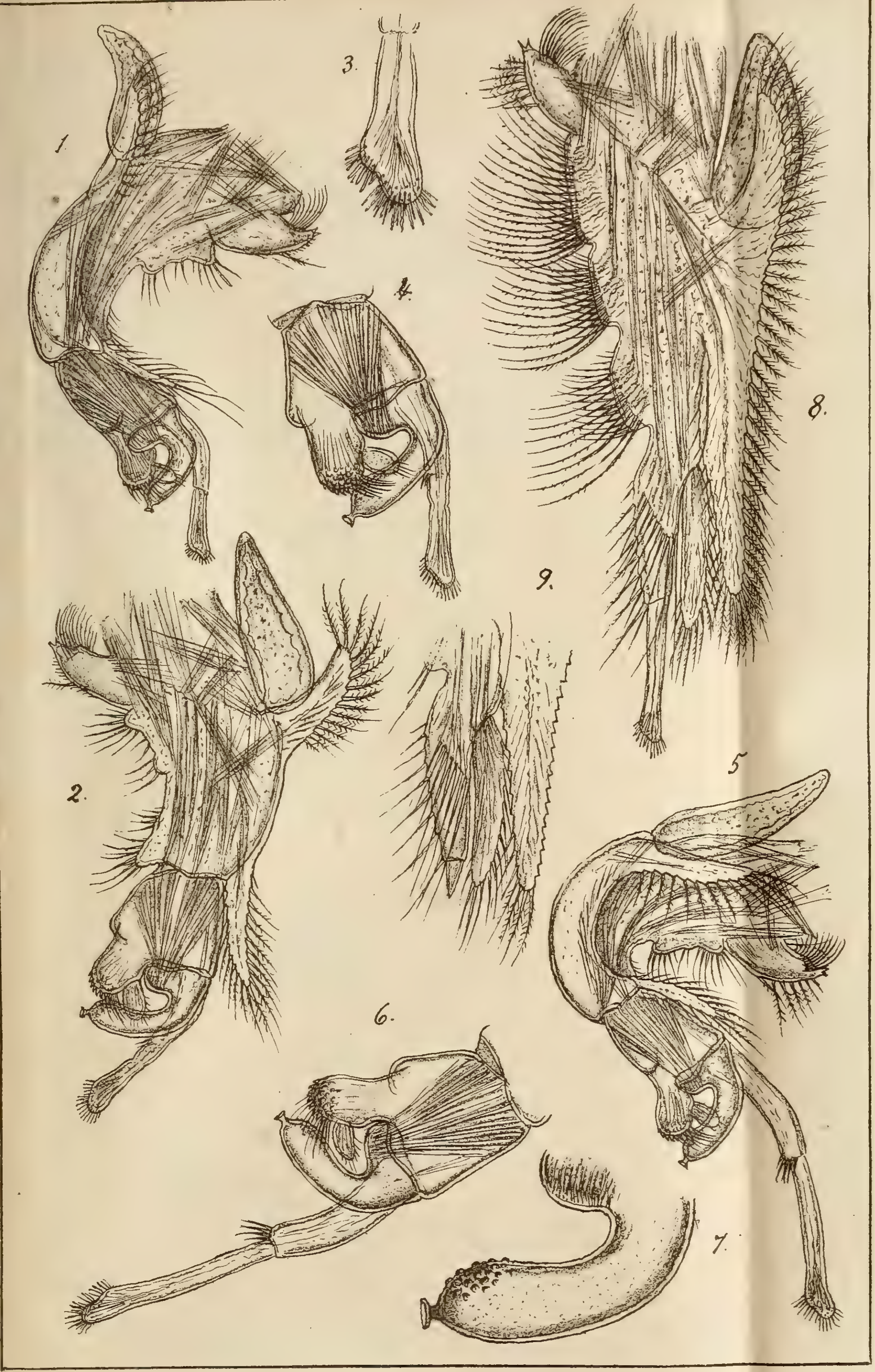

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UDGIVET

AF

AMUND HELLAND, SOPHUS LIE, G. O. SARS OG S. TORUP

ATTENDE BIND, FØRSTE HEFTE

KRISTIANIA
ALB. CAMMERMEYERS FORLAG
LARS SWANSTRØM
JUNI 1896.

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af

Henrik Sundts legat

til fremme af naturvidenskabelige undersøgelser.

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Bergens museum d. 1ste januar 1896.

G. A. Hansen.

Brunchorst.

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