Formation of the solar system form a potential-vortex-natured nebula disk. Part III: Derivation of the behaviours of the sun and the planets

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- natürliche Lebensgrundlagen: Schutzorganisationen
- Umweltschutz, insbesondere Umweltschutzgesetzgebung - Raumplanung: Schweiz. Gesellschaft für Umweltschutz
- Versorgung mit ausreichend und gesunden Nahrungsmitteln: Hochschulen und Bundesbehörden
- Arbeit, Arbeitsplätze, Arbeitszeitverkürzung, Verteilung von Arbeit, Inhalte von Freizeit: Arbeitgeberverbände, Gewerkschaften, Bundesbehörden, Pro Juventute
- Unzufriedenheit der Jugend mit dem gesetzten Lebensraum: Schweizerische Kommission für Jugendfragen

b) Prüfung der von *Lendi* angeregten Idee einer Verbandsbildung der VLP; Prüfung der Grundsatzfrage: - überwiegend öffentliche Träger und Berufsleute wie bisher oder: «Verband der raumwirksamen und planungsbetroffenen Stimmbürger», denkbar ist z. B. eine Dachorganisation ideeller, raumplanungsnaher Vereinigungen,

- Raumplanung braucht trotz ihrer behördlichen Aufgabe zur Interessenabwägung eine politische Unterstützung für die Gewichtung ihrer wesenseigenen Ziele (haushälterische Bodennutzung).

Statt einer Zusammenfassung

Die letzte der Konsequenzen für und mit der Raumplanung könnte zugleich eine erste Konsequenz begründen:

Die Zukunft in sich selbst zu sehen und daran tätig zu werden. Dass sich dann der Umbruch zum Umschwung wandeln könnte, wäre eine durchaus begründete und durchaus wünschenswerte Annahme im Sinne des Auslobers.

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Formation of the Solar System from a potential-vortex-natured Nebula Disk

Part III: Derivation of the Behaviours of the Sun and the Planets

By Yian N. Chen, Winterthur

In the flow model shown in Fig. 11 for the primordial gas disk of the solar system, the transfer of the circulation is considered to be carried out in the outer field by the inward surface wind (much the same as the inward surface flow for the bath-tub vortex), and the pile-up of the dense gas in the inner field is ascribed to the impingement of the jet-like inflow on the central core of the gaseous disk. These different flows will provide the sun and its different planets with quite different behaviours.

The sun with its small swirl velocity

The sun is a central figure of the solar system. If the swirl velocity of the sun equator is compared with the swirl velocities of the planets along their orbits, as shown in the co-ordinate system v_φ and r of Fig. 21, we can infer from the v_φ-distribution being similar to a *Rankine vortex* that the sun was situated within the narrow innermost region of the vortex core of the primordial gaseous disk, whilst the primeval planet Mercury was just near the outer edge of this core. Venus, earth, Mars and the other planets were already in the outer vortex field.

The fact that the infant sun as a very dense gas body only occupied a small part of the vortex core can be attributed to the jet-like inflow shown in Fig. 11b and 11c. As the stream lines 3 were quite radially directed to the centre M, a very high stagnation pressure in the region 4 would be produced according to the theory of impingement of a jet on a wall (see the equi-pressure contour 24 for a simple round jet). In this manner, a very dense lens-like gas body would be established in the narrow central region of the primeval gas disk.

As further shown in Figs. 11b and 14b, the heavy dust would be separated from the jet-like inflow (5 in Fig. 11b) and deposited along the central plane of the gaseous disk. From the behaviour of this inflow as a jet impinging on a wall (Fig. 11c), the deposition appeared to be the thickest in the central region of the disk and to become gradually thinner with the increase of the distance r from the center. We could have the form of a lens for the distribution of the heavy dust, as shown in Fig. 11b. The pile of the heavy element in the central region would increase the local density considerably without influencing the pressure distribution in this stagnation zone of the inflow (4 in Fig. 11c). The effect of the density on the pressure in the freely swimming, disk-like vortex will thus lessen. This supplies a certain degree of the justification of the linearized theory developed.

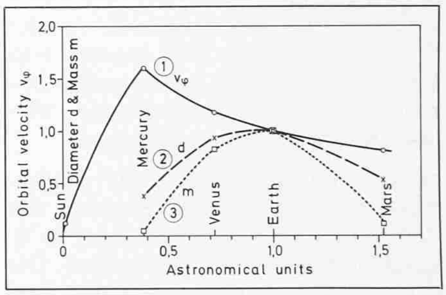


Fig. 21. Swirl velocity v_φ and circulation Γ versus distance r from the Sun for the inner field with an overshoot 3 in the region of Venus

In this manner we have a mechanism that the inflow would not only strengthen the density of the central core (Fig. 11b), but also pile up a heavy element layer along the central plane extending as a thin layer into the field of the potential vortex of the primordial gas disk. The existance of this heavy element layer would not affect the pressure field of the potential vortex owing to its solid state. But it increased the density of the entire core of the gas disk to a great extent.

The dense innermost narrow core was the primordial form of the sun. It would together with the heavy-element layer cause a gravity field which was necessary for the development of the potential vortex of the primordial gas disk to its final stage.

The strong concentration of the mass already in the innermost core of the primordial gaseous disk durning its development as a *Rankine vortex* caused the low swirl velocity of the sun which was generated from this dense innermost core. The outer region, outside this core but inside the orbit of Mercury, would be very thin and light compared with the innermost core. It would therefore contribute very little to the angular momentum of the sun, when it joined the sun after the disintegration of the primordial gas disk into the individual primeval vortices of the infant solar system.

It is thus obvious that the low swirl velocity of the sun originated from its special position in the primordial solar gas disk. As it was within the innermost region of the viscous core of the corresponding *Rankine vortex,* the dynamic viscosity which was very high at the very high temperature of this zone would have prevented it to rotate fast. The small angular momentum of the sun is therefore the natural consequence of the vortex behaviour of the primeval solar system. It is for the first time that we can derive the origin of this phenomenon. This small angular momentum has been a central point of the difficulties for many of the theories concerning the generation of the solar system, e.g. the models suggested by *Laplace* (1792) and *Bodenheimer / Tscharnuter* (1978) (see *H. Fahr* 1981 and *R. Kippenhahn* 1980).

Venus as a special class of vorticies in the primordial solar system

Venus possesses a *series of special properties* compared with the other planets of the solar system. It rotates with a backward sense and shows a very high temperature in its atmosphere (485 degree centigrade over the ground). The wind on it blows with a velocity of 180 m/s in the upper layer of the atmosphere, but of only 4,5 m/s over the ground. This upper-layer wind is much faster than the rotating speed of its equator, whilst the reverse is true for the other planets. This upper-layer wind on Venus reaches 60 times its equator's rotating speed. Only the fluid mechanics that an expansion of the gas from a very high pressure level comes into action can explain this phenomena. That, in addition, the flow has a swirling path, displays a special formation mechanism which is quite unsual for the earthly experiences.

Are these unusual phenomena of Venus counected with its special position in the solar system, so that it is developed from an unusual primordial vortex? Are all these properties the inevitable result of this development? These problems will be treated using the distribution of the swirl velocities and the circulations of the primordial gas disk in the region of Venus, as is shown in Fig. 22. Curve 1 shows the swirl velocities v_φ corresponding to the orbital velocities of the planets, and the peripherical velocity of the equator of the sun. Curve 2 shows their respective circulations rv_φ. The overshoot shown by curve branch 3 of curve 1 occurs just in the region of Venus. Is it this overshoot which charaterizes the special properties of Venus? This question will be answered in the affirmative in the present three chapters by means of the vortex theory developed.

Curve 1 in Fig. 22 for the swirl velocities exhibits the behaviour of a *Rankine vortex,* namely having an inner viscous core extending to Mercury, and an outer field from Venus outward. According to the theory and the experimental result given in Fig. 9a and d, an overshoot is to be expected between the inner core and the outer field, as is illustrated by curve branch 3. This overshoot causes an increase of the circulation inward in the region of Venus, whereby $r^n v_\varphi$ = const ampplies with $n > 1$ (see eq. 42). The local angular velocity will be negative according to eq. (43). Since n will only be slightly greater than unity, this negative value will be very small, meaning a slow rotation of Venus about its own axis in the backward sense. Venus is the only planet having a backward rotation, if Uranus because of the ambiguity of its rotating sense can be disregarded. The period of the backward rotation of Venus of 243 days implies an angular velocity of

$$\omega = -\frac{2\pi}{243} \text{ radiant per day}$$

This angular velocity is 4,2 and 243 times smaller than that of its neighbouring planet Mercury and earth respectively.

The theory developed can thus for the first time explain the origin of the backward rotation sense of Venus. As the explanation is carried out with the help of the primordial gaseous disk of the solar system, the existance of such a disk with such a circulation field in the primordial cloud can thus be considered to be valid once again.

Is there really a greenhouse effect prevailing in the atmosphere of Venus?

The very hot atmosphere of Venus is usually explained to be caused by the greenhouse effect, according to which the solar radiation reaching the surface of Venus will be absorbed and then reradiated by it as infrared rays. The corresponding heat will be completely trapped in the atmosphere, because its primary constituent of carbon dioxide CO_2 (composition of the atmosphere: 96 CO_2 and 3,5% nitrogen with trace amounts of other substances) is a very efficient heat absorber. This carbon dioxide and water vapour, sulfur dioxide, as well as sulfuric acid clouds there have been supposed to play key roles for the trapping of the heat. This trapped heat will be reradiated back to the surface, warming it. It has been claimed that this situation would make the mean surface temperature of Venus about 500°K warmer (compared with 5° and 35°K for Mars and earth, respectively) than it would be in the absence of the thermal infrared opacity of the atmosphere (*J. B. Pollack* 1981).

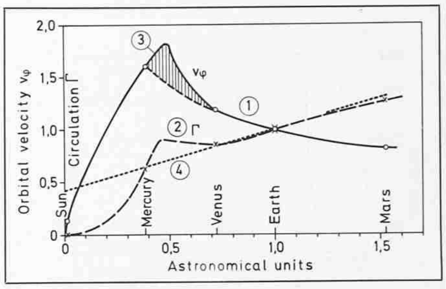


Fig. 22. Swirl velocity v_φ, diameter d and mass m of the planet in the inner field

Usually, a greenhouse effect will be achieved by covering the house by a glas sheet due to its insulating effect for the reradiation in the range of large wavelengths. The air below it will remain stationary without essential convection, so that its thermal conductivity λ_0 is very small. The temperature distribution along the height will have a pattern as shown in Fig. 23. Fig. 24 shows the details of the temperature profile in the vicinity of the glas sheet. The steep temperature drop $\Theta_1 - \Theta_2$ occurs only in the upper layer of the air. A constant temperature Θ_1 of a very high level can be maintained in a thick layer over the ground.

The greenhouse effect on Venus achieved by the favourable heat absorption of carbon dioxide and the sulfuric acid clouds must be equivalent to that of air of very poor conductivity when covered by a glas sheet as shown in Fig. 23. In both cases, the heat will be trapped within the medium. Thus, the temperautre profile over the surface of Venus should be quite similar to that in Fig. 23, if the greenhouse effect would really account for the high temper-

Fig. 23. Temperature profile of a greenhouse

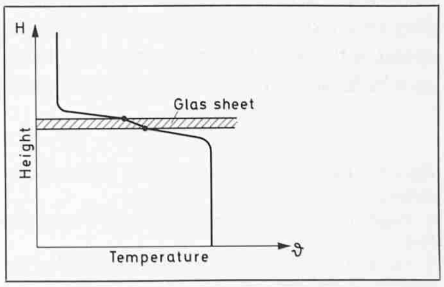
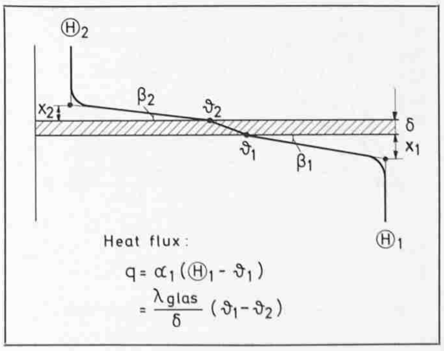
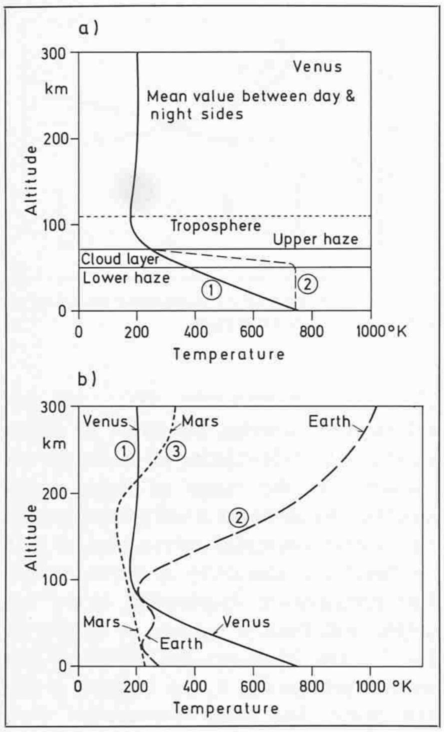


Fig. 24. Temperature gradient through the glass sheet as an insolation layer for infrared reradiation.





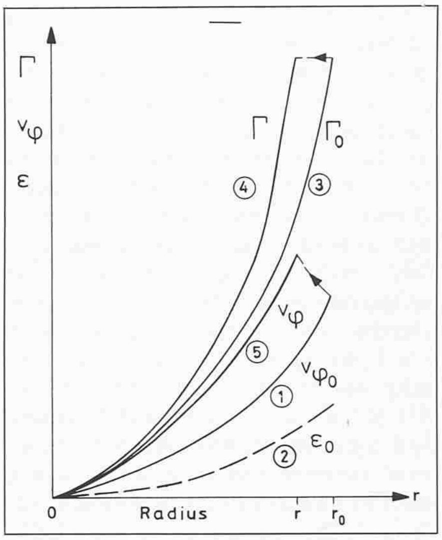


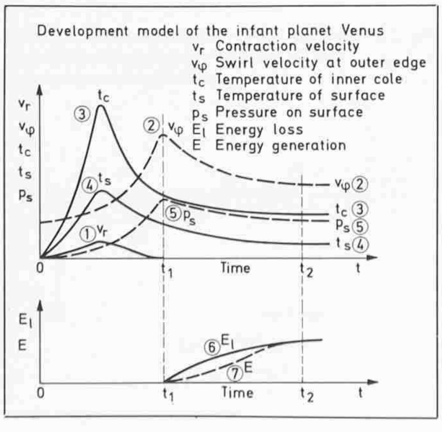
Fig. 26. Transfer of circulation (curve 3 to 4) and swirl velocity (curve 1 to 5) due to contraction of the infant Venus vortex. Curve 2: vorticity ε_0

Fig. 25 (left). a) Measured temperature profile of the atmosphere of Venus (curve 1) and supposed temperature profile caused by greenhouse effect (curve 2)
b) Measured temperature profiles of the atmospheres of Venus, Earth and Mars

ature there. However, the temperature profile really measured, as shown by curve 1 in Fig. 25a (*G. Schubert* & *C. Covey* 1981), is quite different from that required for a greenhouse effect (sketched as curve 2).

This result indicates that the high temperature of 485 degree centigrade on the surface of Venus cannot be caused by the greenhouse effect alone. It must be generated, in addition, by another heat source. This can only be traced to the heat flux conducted from the hot inner core of Venus to its outer crust. Venus seems thus still to remain in a development stage which corresponds to a much earlier period of the earth. This property appears to stay in a close connection with the high-speed of the wind in the upper atmosphere, as will be shown in the following chapter.

Fig. 27. Development model of the infant Venus vortex.
t_1: stage of condensation of the vortex core to a solid body
t_2: stage of the equilibrium of the outer field of the vortex (i. e. the atmosphere)



The quite uniform distribution of the temperatures over the surface of Venus (with a difference of only a few degrees centigrade between the equator and the poles) can bear further witness to the heat source from the interior of the planet. The common suspicion that the greenhouse effect cannot be the only reason for the very high temperature on the Venus surface can thus be supported by the considerations given previously.

There is another piece of evidence in favour of the interior heat source in Venus. This is the temperature distribution along the altitude in its atmosphere. Here, the temperature variations with altitude closely match the dry adiabatic lapse rate in the lowest 35 km, i. e. under the cloud belt (*J. B. Pollack* 1981). This adiabatic gradient also prevails in the lower levels of the atmospheres on Jupiter and Saturn (*A. Ingersoll* 1981). In the case of earth or Mars, however, the lapse rate in the lower atmosphere is substantially less than the dry adiabatic value. For the earth, the observed rate of change is only about two-thirds of the dry adiabatic value (see Fig. 25b). *A. Ingersoll* 1981 states that an adiabatic gradient of the temperatures is usually a sign that the atmosphere is well mixed by convective currents. The temperature of a parcel would change with pressure when moving vertically at a rate such that there is no heat exchange with the surroundings. The adiabatic gradient on Venus, Jupiter and Saturn means that the heat from the surface cannot be carried off by infrared radiation which is blocked by the opacity of the gases in the atmosphere. Thus convection must carry the heat to upper levels where radiation to space occurs. The production of an adiabatic temperature distribution will be especially effective, when the heat source is located below the heat sink.

As further shown by the same author, Jupiter radiates heat from its interior between 1,5 and 2,0 times the amount it absorbs from the sun. The corresponding value for Saturn lies between 2 and 3. The internal heat sources are distributed in a spherically symmetric manner throughout the interior of the planet. The heat sinks are in the atmosphere. The net heat loss is somewhat greater at the poles than at the equator. Only very small departures from adiabaticity would have arisen in the interior to drive the internal heat flow poleward. The atmosphere is effectively short-circuited by the interior. There is no large-scale temperature gradient to disrupt the banding feather of the strong east-west flows in the atmosphere.

The author points out in addition that there are appreciable temperature gradients with latitude on earth and Mars resulting in poleward heat transport in the atmosphere from the tropical region, in which more solar energy is absorbed. This transport across latitude circles makes the atmosphere decidedly nonadiabatic. It is thus obvious that the adiabatic gradient in the atmosphere bears witness to the strong heat supply from the interior of the planet, whilst the nonadiabatic gradient testifies the prevalence of the solar radiation from above as the heat source. As the winds in the upper levels of the atmosphere on Venus also show a clear east-west banding feather, there is a sign of an intensive heat source in the interior of Venus just like in Jupiter and Saturn. The adiabatic temperature gradient in the lower atmosphere makes the similarity between the three planets still more complete.

The pre-condition for a greenhouse effect is the trapping of heat in the atmosphere. Any convective current will be incompatible with it. Such a current would carry heat up to cold layers and thus disrupt the heat trapping. Thus the measured adiabatic temperature gradient, which is an expression for the intensive convection currents in the atmosphere, provides us a further argument to oppose the application of the greenhouse theory to the case of Venus. It must be an interior heat source which generates the high temperature on the surface of Venus.

Overshoot of the circulation curve as cause of the high temperature and the strong wind of Venus

The overshoot in the circulation of the primordial solar gas disk as denoted by curve branch 3 in Fig. 22 supplied the infant vortex of Venus an unusual distribution of the swirl velocities as shown by curve 1 in Fig. 26. The exponent n in the equation

$$r^{-n} v_\varphi = \text{const}$$

increases strongly outward, with the result that the vorticity ε_0 of the vortex will also increase simultaneously according to eq. (43) (see curve 2). Curve 3 shows the corresponding circulation $\Gamma_0 = (r v_\varphi)_0$.
As the vortex contracted in the process of the formation of the planet, the circulation would be conserved during the decrease of the radius, see curve 4 for Γ. This caused an increase of the swirl velocity v_φ (see curve 5). The profile of the latter became steeper and steeper during this contraction.
The development of the vortex to a planet can be imagined to follow the process as given below. When the inner core of the vortex finally condensed to a solid stage, the contraction would be practically stopped. Then, the swirl velocity would cease to increase. This period is denoted as t_1 in Fig. 27. Curve 1 symbolize the contraction velocity and curve 2 the swirl velocity at the outer edge of the vortex. The temperature in the inner core and that on the surface of the infant planet are imagined to have the course of curve 3 and 4, respectively. The pressure p_s on the surface is sketched as to follow curve 5. Until time t_1, the vortex can be supposed to be self-sustained. There is a kind of equilibrium existing from the outer edge to the inner layer of the vortex.
As the profile of the swirl velocities of the vortex strongly deviated from a potential vortex, the viscosity in it would affect the further development of the vortex after the period t_1. The swirl velocity on the outer edge of the vortex, i. e. the wind velocity in the upper layer of the atmosphere, had a very large gradient dv_φ/dr (see Fig. 28). (The damping effect was especially strong). It would decrease in the course of time, accompanied by a great energy loss E_l, as shown by curve 6 in Fig. 27. The energy loss in the inner layer of the vortex, i. e. the lower layer of the atmosphere over the planet surface, was much less owing to the smaller gradient $dv_{\varphi/dr}$. Thus the equilibrium condition mentioned was destroyed. The energy level in the lower layer of the atmosphere became higher than that in its upper layer.
The high temperature t_s and the great pressure p_s on the surface would generate a flow upward following this energy gradient. This energy generation E would apparently have a course of curve 7 in Fig. 27. This generation increased with time just in accordance with the increase of the energy gradient caused by the increase of E_l (curve 6), until an equilibrium between the generation E and the loss E_l was reached at time t_2, see Fig. 27. There would be a much slower ascend in the later period (curve 7), because the pressure p_s

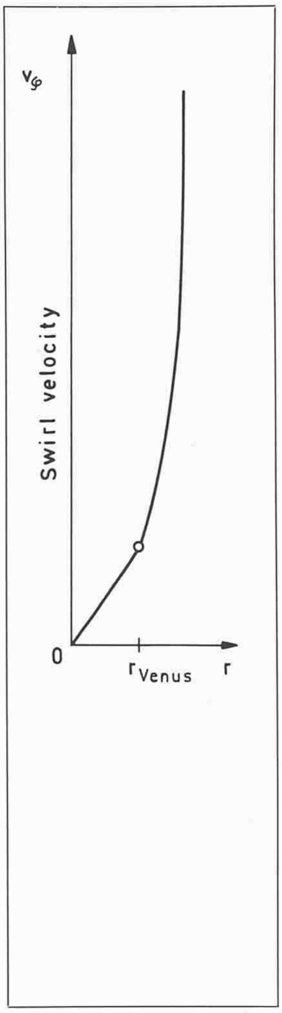


Fig. 28. Swirl velocity of the outer field of the infant Venus vortex (i. e. the wind velocity of the atmosphere)

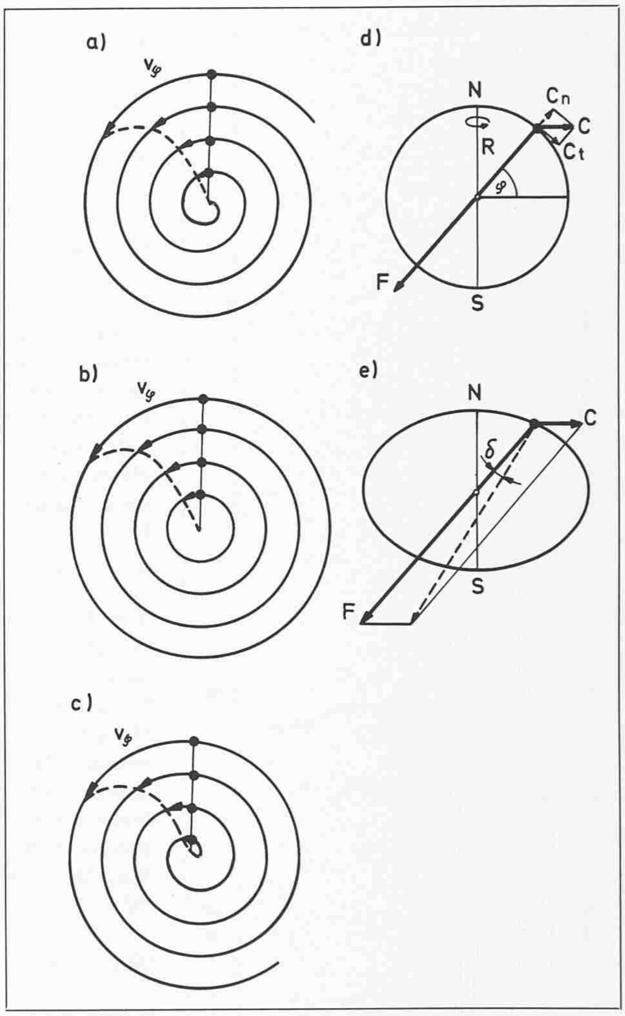


Fig. 29. Development of the primordial vortex of Venus from the overshoot of the swirl velocity to the present wind pattern of the atmosphere:
a) a vortex-sink during contraction period of the vortex
b) a pure vortex at the end of the contraction
c) a vortex-source for the present stage of the wind pattern

and the temperature t_s of the surface had decreased in the meantime due to this energy transition, see curves 5 and 4. A practically new equilibrium could thus be established at time t_2. Afterwards, the swirl velocity v_φ in the upper layer of the atmosphere, the pressure p_s and the temperature t_s on the surface would retain these final values so far as the energy balance in the vortex is concerned.
The development of the vortex from the overshoot of the primordial circulation of the solar gas disk to the present wind pattern in the atmosphere, as sketched in the present chapter, can thus be divided into *three* periods:

- Increasing of the swirl velocity during the contraction of the primordial planet, corresponding to a combination of a vortex and a sink (Fig. 29a);
- Cease of this increasing owing to the ending of the said contraction, leading to the formation of a pure vortex with a very high swirl velocity in the outer layer (Fig. 29b);
- Generation of a source flow from the planet surface to the upper layer of the atmosphere due to the energy gradient (Fig. 29c), whereby the planet was acting as a gas turbine forcing the flow along the spiral path prescribed by the vortex (being developed from the circulation overshoot of the primordial solar gas disk). This spiral path can be compared with the channels of the impeller blades of a gas turbine. The heat-generating inner core of the planet is then the combustion chamber of the gas turbine, and its mantel is the heat exchanger. Venus can thus be compared with a close-circle-typed gas turbine.

From the vortex model presented in these three chapters, we can conclude that the high temperature over the ground of Venus would originate only in a small part from the greenhouse effect. The main source for it appears to be the heat from the inner core of the planet.
The average temperature of the thermosphere of Venus on its day and night sides scarcely increase with the height as shown by curve 1 in Fig. 25a, this in contradiction to those for the earth and Mars (see curves 2 and 3). This behaviour might be interpreted as that a high vacuum prevails in this thermosphere. In other words, the atmosphere of Venus possesses practically only heavy molecules like carbon dioxid

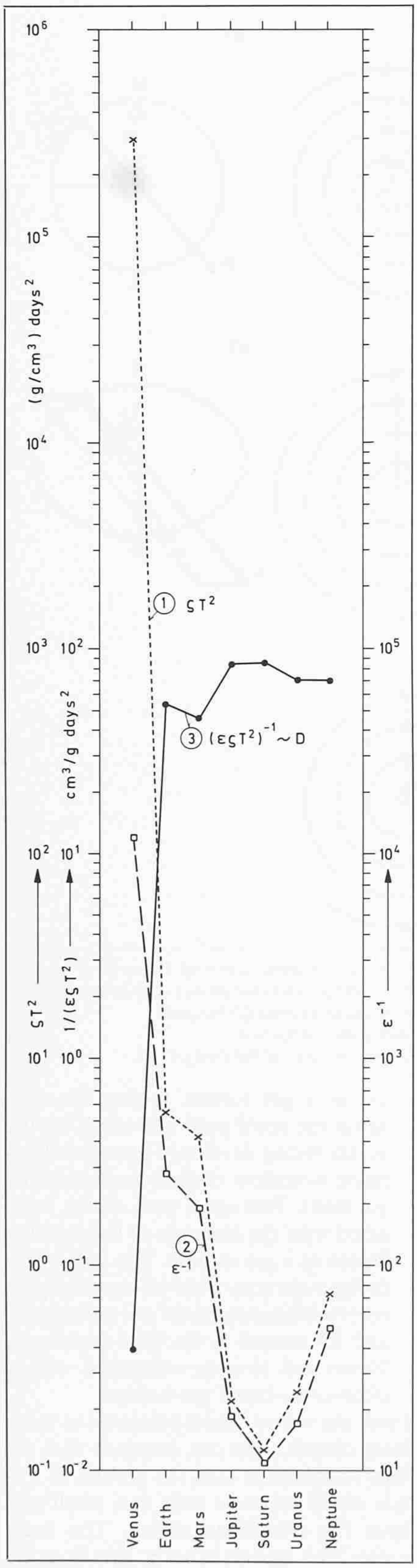


Fig. 29f

(96%) and nitrogen (3.5%), without any essential components of light ones like hydrogen. Therefore, the escape of molecules into the space will be nearly suppresed. (At an altitude of 500 km the oxygen atom prevails owing to the dissociation of molecules CO_2 or O_2. The number densities 4 m^3 are $0 = 3\times10^{13}$ and $H = 2\times10^{10}$ for earth, but $0 = 2\times10^{10}$ and H→zero for Venus.) This could also help to keep the temperature high in the atmosphere, and thus slowing down the development of Venus.

The void of hydrogen in the Venus atmosphere suit well to the theory of a strong surface wind blowing over the primordial solar gas disk, and therefore carrying away the light molecules towards the planet Jupiter. There is still another piece of evidence for the heat originating from the interior of Venus. The planet is not an ideal sphere. The pole diameter is always less than the equator diameter owing to the centrifugal force arising from the rotation about its pole diameter as axis. The tangential component of the centrifugal force C:

(45) $C_t = mR\omega^2 \cos\varphi \sin\varphi$

in which m = mass, R = radius, ω = angular velocity, φ = latitude, is directed to the equator (Fig. 29d). This component will try to drive the mass to the equator *(W. H. Westphal* 1950), and thus to cause a flattening of the sphere to the form of an ellipsoid, whose pole diameter is compressed to a smaller length than that of the equator diameter (Fig. 29e). The ratio between the compression ΔR and the equator radius R:

(46) $\varepsilon = \Delta R \,/\, R$

is then a scale for the deformation of the sphere.

If the sphere of the planet cannot exert any resistance against this deformation, the surface of the ellipsoid will always stay perpendicular to the resultant of the centrifugal force C and the gravity force F:

(47) $F = GmM \,/\, R^2$ (M = mass of the planet),

see Fig. 29e. Then the ratio C/F will determine the angle δ of the resultant force, which is proportional to the deformation. Then the expression

(48) $D = C \,/ (\varepsilon F)$

will reach a limit value.

If, however, the soil of the planet is rigid with a high value of the Young modulus, the deformation ε will be less. In this manner, the above expression D will not go as low as down to the limit value. Therefore D can be considered as a measure for the rigidity of the planet.

The ratio of the centrifugal force to the gravity:

$$(49)\; C \,/\, F = \frac{mR\omega^2}{GmM/R^2} \sim \frac{mR\omega^2}{mmR^3/R^2} \sim \frac{\omega^2}{m} \sim \frac{1}{\rho T^2}$$

in which T denotes the rotation period (in days) and ρ denotes the mean density (in g/cm³), can be evaluated using the known data. The value ρT^2 is shown in Fig. 29f as curve 1, and the reciprocal compression ε^{-1} is shown as curve 2. The rigidity $D \sim 1 \,/ (\varepsilon\rho T^2)$ can then be calculated as given in this figure as curve 3.

According to curve 3, the rigidity is the highest for Jupiter and Saturn, followed by Uranus and Neptune, owing to the practically incompressibility of the liquid hydrogen and helium under very high pressure in their shells. Then come earth and Mars with somewhat lower values. All these values lie rather in the same range. The rigidity of Venus, however, is by a factor of 10^4 lower. The corresponding value of 0,039 might already approach the limit as given above.

The data of ε for Venus may be not accurate enough *(H.-M. Hahn,* p. 118). But it cannot be wrong by a factor of 10. If we allow this factor in the calculation, the corrected value of the rigidity of Venus is still by a factor of 10^3 too low compared with others.

The very low rigidity of Venus can only be attributed to the very high temperature of its interior. It seems that the soil of Venus is already no longer capable of making any resistance against the centrifugal force. The high temperature of 485 centigrade can thus not be restricted to a thin layer of the surface of the crust. The temperature must be still higher inward in order to reduce the rigidity to such a low value. This result leads once more to the conclusion that there must exist a very active inner core in Venus supplying heat from the center outward to the surface.

From the above consideration we find further confirmation that the high temperature in the lower layer of the atmosphere cannot be caused merely by the greenhouse effect. Otherwise, this high temperature would be restricted to a thin layer of the surface because of the poor thermal conductivity of the soil, if the planet would have really cooled down in the interior. This cooling-down has already proved to be not the case as shown previously.

Jupiter with its Trojan asteroid groups and moon clusters

Jupiter possesses a very curious phenomenon that it is accompanied by two Trojan asteroid groups in its revolution orbit around the sun, one group in front of it and the other behind it (Fig. 30). It is to be expected that this phenomenon is closely connected with its special situation in the solar system.

Jupiter is just situated in a zone in which the two surface winds 7 and 2 (the outward blowing wind and the inward one, respectively, as shown in Fig. 11b) meet according to the model developed. The wind 7 can be supposed to be warmer than the wind 2, because the former comes from the central warm region, and the latter comes from the outer cold region. Fig. 31a shows the variation of the swirl velocity v_φ of the wind along its radial path r. Curve 2 denotes wind 2 and curve 7 denotes wind 7, whilst curve 0 indicates the law $r^{1/2}v_\varphi$ = const for the rotating pattern of the gaseous disk. Curves 2 and 7 follow the law of the transfer of the circulation, namely rv_φ = const. Therefore, curve 2 goes over curve 0, but curve 7 goes below it. The two surface winds will be deflected to the right due to the difference between these curves (coriolis effect). As these two winds meet at the circle of the primeval Jupiter, they impinge on each other with both the opposite radial and the tangential components. The radial componets will cause the stagnation of the winds, forming a front, but the tangential components will lead to the shear of them.

The front between these two winds with different temperatures coming from the opposite directions has its counterpart on the earth. It is, for example, the polar front at the 50–60 degree latitude between the westeries coming from the subtropical region and the easterlies coming from the polar region in the northern Hemisphere of the earth (see Fig. 32). As these two winds have the opposite directions along the front, an instability will arise in the free shear layer due to shearing of the swirl flows. This will lead to the formation of a vortex group along the front. The formation process of one vortex is given in Fig. 33 (*A. Miller* 1971).

The parallel flow (a) takes first a wavy form (b), so that a counter-clock vortex on the cold air side will be finally formed (c, d, e, f). Such a vortex group as encountered in the polar front is called a cyclone family, as shown in Fig. 34 (*W. Eichenberger* 1977).

On the side of the warm easteries, a jet-stream will be generated, associated with very strong turbulence activity along the hang of the low pressure region (see Fig. 35 for the jet-stream and Fig. 36 for a cross-section of it with the turbulence field). Fig. 37a and b show, how the jet-stream travels along the hangs of the low pressure regions, in which steep pressure gradients prevail. Picture a shows the 300mb isotachs (knots) and the axis of a jet stream, and picture b shows the corresponding 300mb contour lines (hectofeet).

The result that a group of vortices with strong turbulence will be formed along the low pressure zone of the polar front can be applied to the front between the surface winds 7 and 2 over the primordial solar gaseous disk in our fluid dynamic model, as shown in Fig. 31b. The front F of these two winds 2 and 7 along the circle of the primeval Jupiter was composed by a pat-

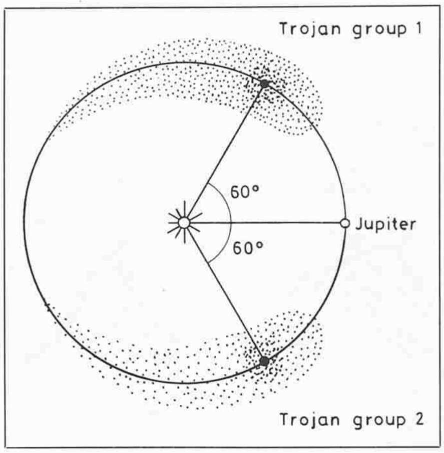


Fig. 30. Jupiter with two Trojan asteroid groups

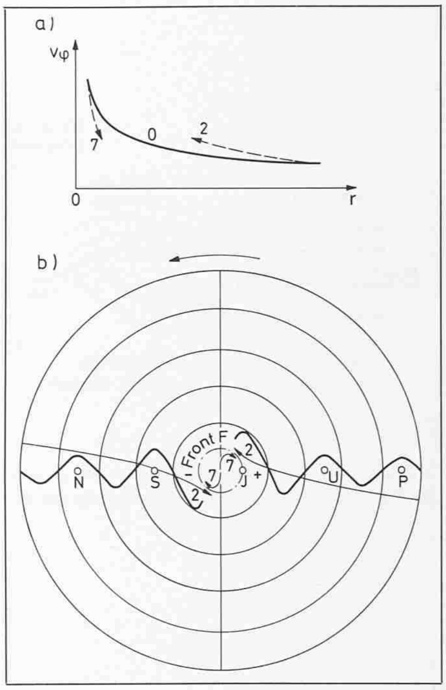
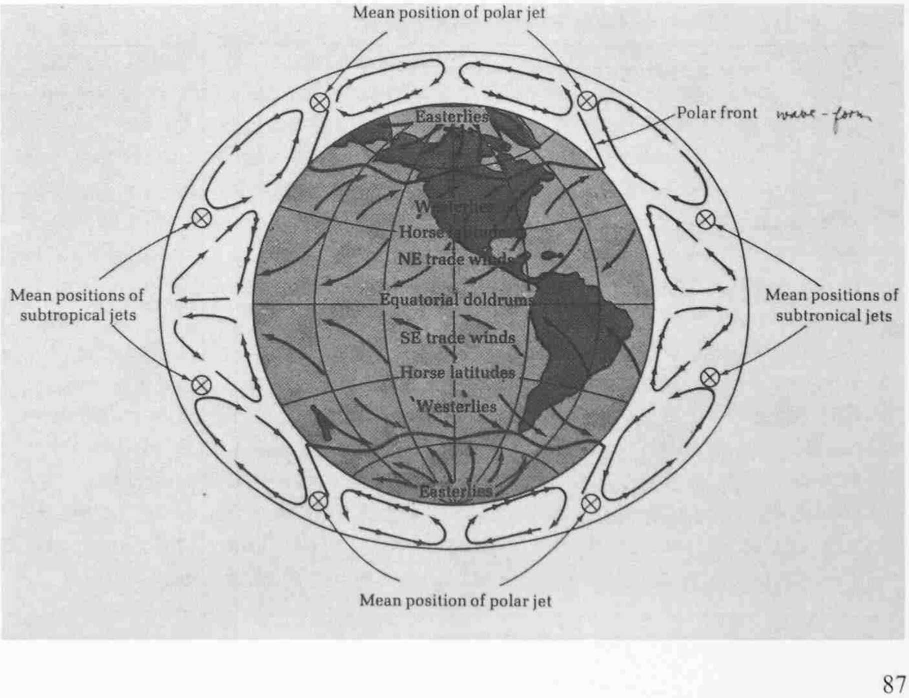


Fig. 31 (right). a) Rotating pattern of the primordial nebula disk (curve 0 for $r^{1/2}v_\varphi$ = const) and variations of swirl velocities of the surface winds 2 and 7 (according to rv = const)
b) Front between surface winds 2 and 7

tern of a high pressure H and a low pressure L situated in the opposite directions according to the theory developed (see Fig. 38a, as well as compare with + and –, respectively, in Fig. 31). Strong turbulence would be formed on the front along the low pressure zone. The greater the pressure gradient, the stronger the turbulence would be. The stretched front with its pressure distribution of H and L is given in Fig. 38b. The absolute value of the pressure gradient is the greatest in the two side zones s of the low L. Therefore, it can be supposed that the turbulence would be the strongest there.

The turbulence zone is denoted by the shaded area T in Fig. 38a, whose width symbolizes both the intensity and the extension of the turbulence. This turbulence would consume considerable energy from the vibrating system with the result that the gas in the turbulence zone could not take part in the vortex generated around the high pressure center, when the primordial gas disk was disintegrated into individual vortices during its further development. As the turbulence is composed by a great number of eddies of different sizes and intensities, we have a field of small vortices which will undergo the same process of the development as the vortex of the infant planet itself. The small vortices would then finally developed into two groups of small solid bodies: the Trojan asteroid groups, as shown in Fig. 30. The distances of these two groups to the devel-

Fig. 32. Polar front between the westeries coming from the subtropical region and the easteries coming from the polar region in the Northern Hemisphere of the Earth (A. Miller 1971)



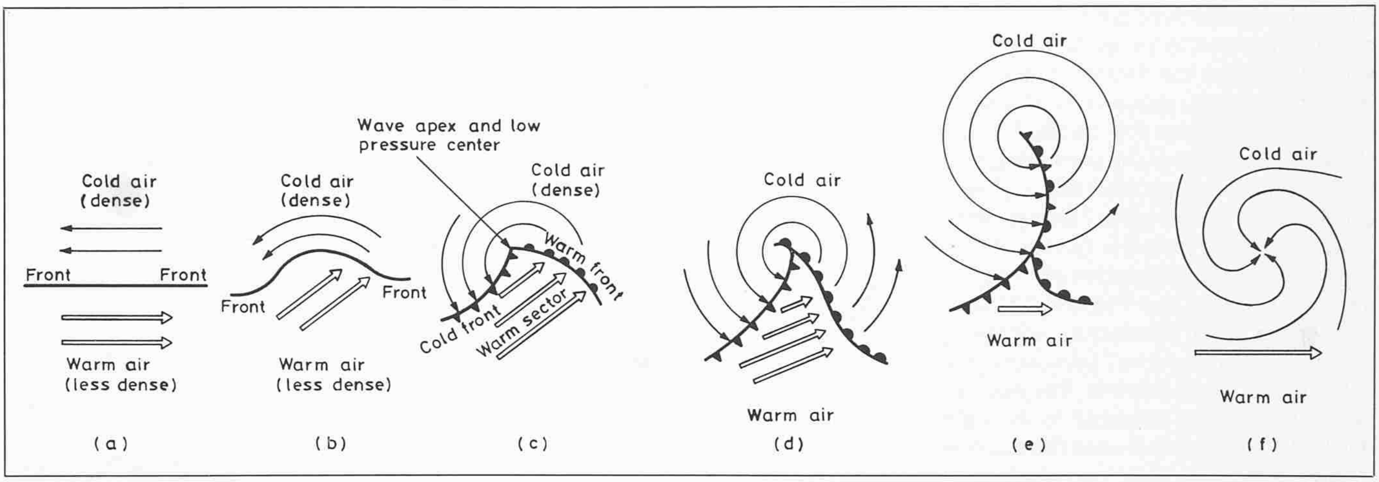


Fig. 33. Formation of a vortex on the polar front (A. Miller 1971)

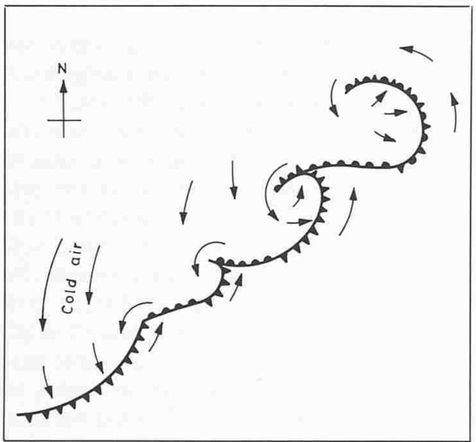


Fig. 34. Formation of a vortex group on the polar front (a cyclone family) (W. Eichenberger 1977)

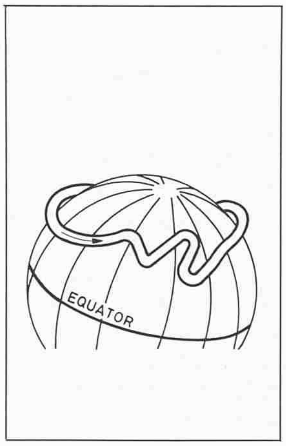


Fig. 35. The jet-stream along the polar front (W. Eichenberger 1977)

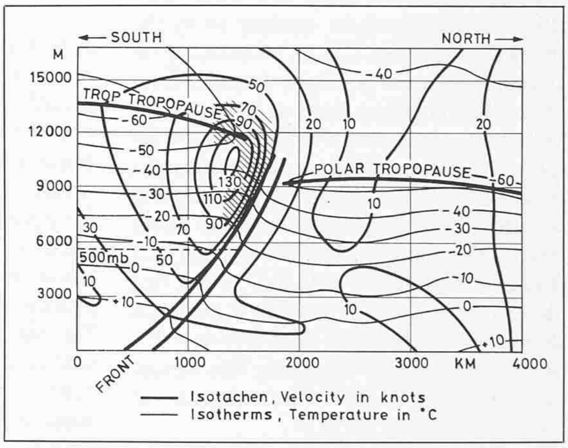
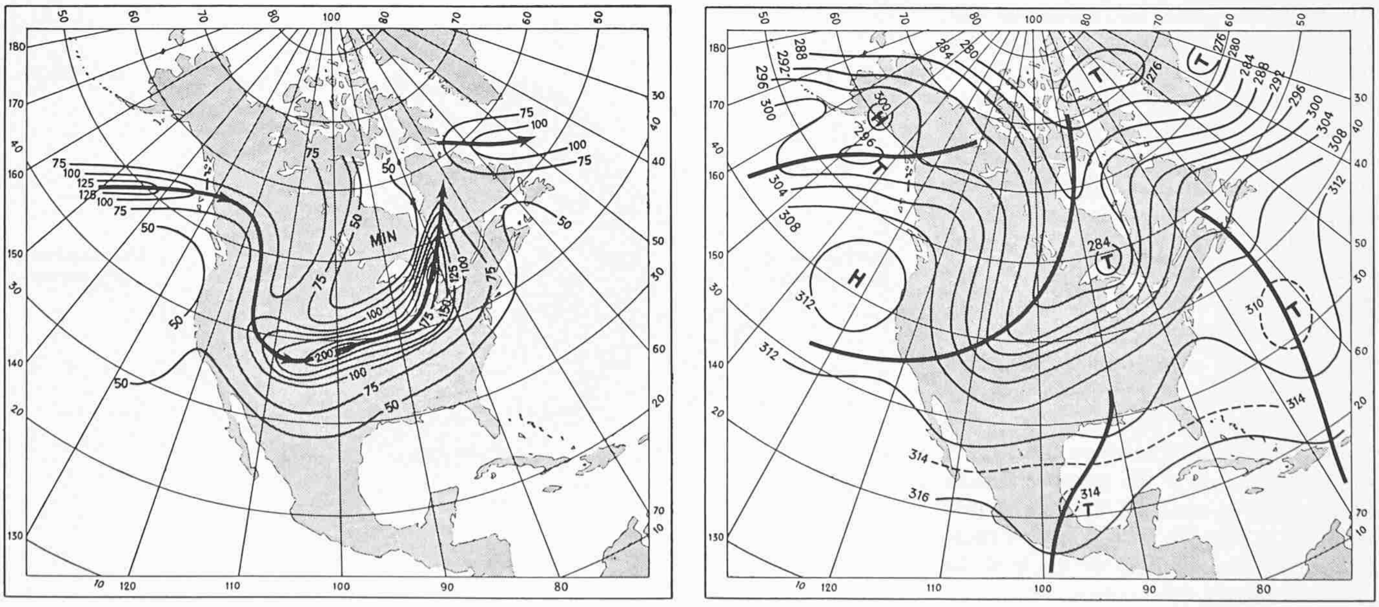
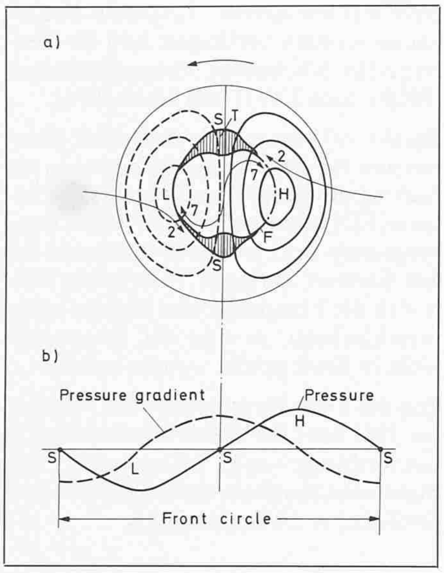


Fig. 36. A cross-section of the jet-stream \\\\\\\ = strong turbulence (W. Eichenberger 1977)

Fig. 37. Path of a jet-stream with isotachen and isohypsen





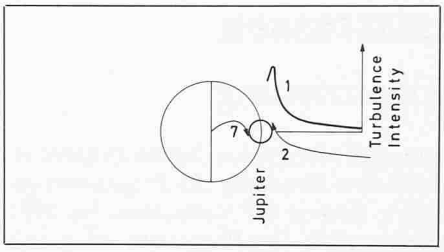
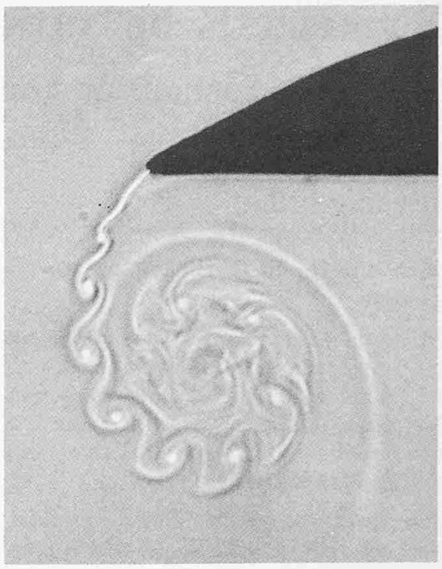


Fig. 39. *Turbulence formation in front of the infant planet Jupiter*

Fig. 38 (left). *Formation of turbulence field on the frontal circle between surface winds 2 and 7, i. e. on the orbital circle of the infant planet Jupiter*

Fig. 40 (right). *A turbulent vortex consisting of a number of small edge eddies (Pierce 1961)*



oped planet Jupiter will be determined by the mutual gravity fields of these three bodies with the sun. The theoretical form of the Trojan group shown in Fig. 38a corresponds very well to the real appearance of it (Fig. 30).

Referring to Fig. 38a, the turbulence zone would extend to the outer region of the primeval vortex of Jupiter. The impingement of the radial components of the two surface winds 2 and 7 on the developing high pressure center (acting as a dense lens-like body) would produce further turbulence in the border zone of the body to the flow. This result can be derived from the well-known phenomenon in the fluid dynamics that a flow when streaming against a bluff body, for example a circular cylinder, will become the more turbulent, the nearer it approaches the surface of the body. The stagnation of the flow on this surface results in the deceleration of it and thus in the production of turbulence, as shown by curve 1 in Fig. 39. For the case of a circular cylinder the turbulence can be raised to 25 to 70 times as high according to the measurements *(Sadeh* 1980). The turbulence is the strongest on the outer edge of the boundary layer zone on the body surface caused by the stagnation of the flow. According to the measured results on the bath-tub vortex, the tangential component of the surface wind outweighs its radial component considerably. The latter is then responsible for the excitation of the tidal waves of the primordial gaseous disk, as shown in the theory developed in the paper. It can thus be argued that the outer edge of the lens-like disk of the primordial vortex of the planet Jupiter would be rather turbulent. This derivation can be verified by the distribution of the outer moons of Jupiter.

When the primordial vortex system of Jupiter again dissolved into a central vortex (i. e. Jupiter itself) and a series of smaller satellite vortices, the ones in the outer orbits would be situated in the turbulent zone mentioned. Such a satellite vortex would exhibit a pattern as shown in Fig. 40 obtained in a laboratory investigation (carried out by *Pierce* 1961 for the generation of a vortex behind an edge). The vortex embodies a great number of small eddies, the so-called edge eddies, along its spirally winding path due to the turbulent behaviour of the flow.

The moon system of Jupiter is compiled in Fig. 41. Whilst the moons 1979 J1 to Kallisto of the inner field are spaced in a normal pattern, the moons of the outer field are grouped around two centers, one having the four moons Leda to Lysithea and the other having the four moons Ananka to Hades. As will be shown in a later chapter, the radii of the two centers to the planet Jupiter stay in a ratio corresponding to that for the planets of the sun. It is thus manifested that each group of the moons must originate from a common primeval turbulent vortex composed by the small eddies representing the infant condition of the moons, as sketched below the group in Fig. 41. These small eddies would be developed into a cluster of moons orbiting in a belt about the center of their parent vortex during the ancient development period. These moons would soon separate from each other due to the difference in their orbital velocities.

Fig. 41 (right). *Outer moon clusters of Jupiter as eddy groups in the primordial vortex*

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