Fluid flow process pdf

Fluid flow is part of fluid mechanics and deals with fluid dynamics. It involves the movement of fluid exposed to unbalanced force. This movement continues as long as unbalanced forces are used. For example, if you pour water from a mug, the water speed is very high above the lip, moderately high approaching the lip, and very low at the bottom of the mug. An unbalanced force is gravity, and the flow lasts as long as water is available and the mug is tilted. The types of liquids the ideal liquid liquid is considered ideal when it cannot be compressed and viscosity does not fall into the category of ideal liquid. It's an imaginary liquid that doesn't really exist. Real liquid All liquids are real, as all liquid has viscosity. Newtonian fluid When the liquid is subject to newtonian viscosity law, it is known as Newtonian fluid. Non-Newtonian fluid When the liquid is not subject to Newton's viscosity law, it is known as non-Newtonian fluid. Ideal plastic liquid When haircut stress is proportional to the speed gradient and the stress of removing the snive more than the value of the yield, it is known as the ideal plastic liquid. Unstoppable liquid When the density of the liquid does not change with the use of external force, it is known as an irrepressible liquid. Compressible liquid When the density of the liquid changes with the use of external force, it is known as a compressible liquid. The table below represents the density and viscosity of different types of liquid Types Liquid Type Viscosity Ideal Liquid Permanent zero real liquid Variable non-zero Newtonian liquid Constant / Variable (Thu (Frak-matrm d'mathrm'd)) d'u'mathrm'd'd) Incompressable liquid Permanent Non-zero/zero liquid To learn more about other fluid-related concepts, the following links are: Fluid Fluid Dynamics Properties - Hydrostatic Movement Pressure Classification based on the number of Mach Incompressable Flow has M'lt;0.3. The compressed subsonic flow has an M between 0.3 and 1. Different types of fluid flow are represented in the graph below: The types of fluid flow flow have all kinds of aspects - steady or unsteady, compressed or incompressible, viscous or incoherent, and rotating or and protective, to name a few. Some of these characteristics reflect the properties of the liquid itself, while others focus on how the liquid moves. A steady or unstable flow of fluid flow can be steady or unstable, depending on the speed of the liquid: Steady: In a steady flow of liquid, the fluid rate is constant at any point. Non-stationary: When the flow is unsteady, the fluid speed may differ between any two points. The viscous or incoy flow of liquid flow can be viscous incoy. The viscosity is fluid thickness, and very gloppy liquids such as motor oil or shampoo are called viscous liquids. The fluid flow rate is an equation of mass flow speed of the massive liquid through the unit area. Simply put, it's a mass movement per unit of time. The formula for mass flow speed is as follows: (Mass; stream); Speed : A ; V.) From the equation we can see that the speed of mass flow depends on the density, velocity and area of the transverse section of the liquid. Decided example A liquid moves through the pipe 15 m/s, the tube has a transverse area of 0.4 m2. If the fluid density is 1.5 grams/m3, what is the amount of mass flowing through the tube? To calculate the total mass of fluid flowing through the tube, we use (Mass, stream), speed, hoo, A, B), replacing the values in the aforementioned equation, we receive (Mass, flow, speed 1.5 × 15 × 0.4 and 9.g/s) the flow of liquid through the pipe ranges within its size. The table below shows the fluid flow capacity, depending on its size. Размер трубы (в дюйме) Максимальный поток (в гал/мин) Скорость (в фут/с) Потеря головы в (фут / 100 футов) 2 45 4,3 3,9 2,5 75 5,0 4,1 3 130 5,6 3,9 4 2 60 6,6 4,0 6 800 8,9 4,0 8 1600 10,3 3,8 10 3000 12,2 4,0 12 4700 13,4 4,0 x14 6000 14,2 4,0 16 8000 14,5 3,5 18 10000 14,3 3,0 20 12000 13,8 2,4 24 18000 14.4 2.1 Аспекты механики жидкости с участием потока Часть серии onContinuum механики Законы Сохранения Масса Momentum Энергии Неравенство Клаусиус-Духем (энтропия) Твердая механика Деформация Эластичность линейной Пластичности Хук закон Стресс Конечная штамм Бесконечно-силовая совместимость Совместимость Контактная механика фрикционной теории материалов Механика жидкости механики жидкости Принцип динамики Архимеда Принцип Бернулли Навье-Стокс уравнения Poiseuille уравнения (ru) Закон Паскаля Viscosity (Ньютоновский и неньютоновский) Плавучесть (ru) Смешивание Давление жидкостей поверхности напряженности Капиллярных действий Газы Атмосфера Бойл закон Чарльза Гей-Lussac закон Комбинированный закон газа Плазма Реология Вискоэластичность Реометр Реометр Смарт жидкости Электрореологические Магнитореологические Феррофлюиды Ученые Бернулли Boyle Cauchi Charles Euler Gay-Lussac Hooke Newton Assuming a viscous environment running from left to right, the diagram shows the distribution of pressure as the thickness of the black line and shows the speed in the boundary layer like purple triangles. Green vortex generators encourage the transition to turbulent streams and prevent a reverse current, also called the separation of the flow from the high pressure area at the back. The surface in front is as smooth as possible or even uses the shark as the skin, as any turbulence here increases the energy of the air flow. Rooting on the right, known as Kammback, also prevents from the high pressure area at the back of the spoilers to the converged part. In physics and engineering, fluid dynamics is a subdisciplinary fluid mechanic that describes the flow of liquids and gases. It has several subdisciplines, including aerodynamics (studying air and other gases in motion) and hydrodynamics (research of liquids in motion). Fluid dynamics have a wide range of applications, including calculating forces and moments on airplanes, determining the speed of mass oil flow through pipelines, predicting weather conditions, understanding nebulae in interstellar space, and modeling the detonation of fission weapons. Fluid dynamics provide the systemic structure that underpins these practical disciplines, which covers empirical and semi-imperial laws derived from the measurement of flow and used to solve practical problems. Solving the fluid dynamics problem usually involves calculating the different properties of the liquid, such as flow rate, pressure, density and temperature, both the functions of space and time. Until the twentieth century, hydrodynamics was synonymous with fluid dynamics. This is still reflected in the names of some fluid dynamics topics, such as magnetohydrodynamics and hydrodynamic stability, which can also be applied to gases. Equations by the Basic axioms of fluid dynamics are laws of preservation, in particular, the preservation of mass, the preservation of linear impulse and the preservation of energy (also known as the First Law of Thermodynamics). They are based on classical mechanics and are modified in quantum mechanics and general relativity. They are expressed by the Reynolds theorem. In addition to the foregoing, the liquid is supposed to obey the continuum assumption. Fluids are made up of molecules that collide with each other and solid objects. However, the continuum assumption suggests that fluids are continuous rather than discrete. Consequently, it is assumed that properties such as density, pressure, temperature and flow speed are clearly defined in infinitesimal points of space and constantly change from one point to another. The fact that the liquid consists of discrete molecules is ignored. For liquids that are dense enough to be a continuum, do not contain ionized species, and have a small flow rate relative to the speed of light, the pulse equations for Newtonian liquids are the Navier-Stokes equation - which is a nonlinear set of differential equations that describes fluid flow, stress depends linearly on gradients of flow rate and pressure. Unsupted equations do not have a common closed-form solution, so they are primarily used in computational fluid dynamics. Equations can be simplified in different ways, all of which make them easier Some of the simplifications allow for some simple fluid fluid dynamics must be resolved in a closed manner. In addition to the equations of mass, pulse and energy saving, the thermodynamic state equation, which gives pressure as a function of other thermodynamic variables, is required to fully describe the problem. An example of this would be an ideal gas state equation: p - you T M 'displaystyle p'rho s'rho R_'u'T'M', where p is pressure - density, T - absolute temperature, while Ru is a constant gas, and M is a moly mass for a particular gas. Laws on the preservation of the Three Conservation Act are used to address fluid dynamics problems, and can be written in an integral or differential form. Conservation laws can apply to a region of the flow called a volume control. The amount of control is a discrete volume in the space through which the liquid is supposed to flow. Integral formulations of conservation laws are used to describe changes in mass, pulse or energy within the scope of control. The differential language of conservation laws uses Stokes's theorems to give an expression that can be interpreted as an inalienable form of law applied to an infinitesimal volume (at a point) in the flow. Mass continuity (preservation of mass) The rate of change in the mass of the liquid inside the control volume should be equal to the pure speed of the flow of liquid into volume. Physically, this statement requires that the mass not be created or destroyed in the amount of control and can be translated into an integral form of the continuity equation: ∂ ∂ t ∭ V d v Viha --·---------------------------- , Display-rod is fluid density, u is the vector of flow speed, and t - time. The left side of the above expression is the rate of mass gain in volume and contains a triple integral over the amount of control, while the right side contains integration over the surface of the mass control volume convected into the system. Mass flow into the system is considered as positive, and since the normal vector to the surface is opposite to the meaning of the flow into the system the term is nullified. Differential form of continuity equation, by the theorem of divergence: ∂ No ∇ · ∂ t . is a statement that any change in the pulse of the liquid within this volume of control will be associated with the pure flow of momentum into the volume and action of external forces acting on the liquid in volume. ∂ ∂ t ∭ V q u d V . S display style (scenario S) (u · d S) u u displaystyle (rho mathbf (u) cdot dmathbf (S) Mateff (S) - ∭ V f body d V - F surf (display display style display) , the term on the left is a pure change of momentum in volume. The first term on the right is the net bet at which momentum is convected in volume. because the pulse entering the system is considered as positive, and the norm is the opposite of the direction of u'displaystyle (mathbf) and pressure forces. The third term on the right is a pure acceleration of mass in volume due to any body forces (here is represented by fbody). Surface forces, such as viscous forces, are represented by the F surf (display)mathbf (F), pure force due to the forces of the haircut operating on the surface of the volume. The pulse balance can also be written for moving volume control. Below is the differential form of the momentum-saving equation. Here the volume is reduced to an infinitesimal point, and the forces of the surface and the body are counted in one common force, F. For example, F can be extended into the expression of frictional and gravitational forces acting at the point of flow. D u D t - F - ∇ p -abla p (in aerodynamics) in aerodynamics air is considered a Newtonian liquid, which involves a linear relationship between stress stress (due to internal friction) and the speed of fluid voltage. The aforementioned equation is a vector equation in a three-dimensional stream, but it can be expressed as three scalable equations in three directions of coordinates. Maintaining momentum equations for a compressed, viscous case of flow is called the Navier-Stokes equations. Saving energy, although energy can be converted from one form to another, the total energy in the closed system remains constant. Д д д д д-р Д т т ∇ · (к Φ ∇ T) h является специфическим enthalpy, k является теплопроводностью жидкости, T является температура, и Φ «дисплей »Phi » является вязкой функции рассеивания. The viscous scattering function regulates the rate at which the mechanical energy of the stream is converted into heat. The second law of thermodynamics requires that the term scattering always be positive: viscosity cannot generate energy within the control volume. Expression on the left Derived. Squeezed against the irrepressible flow All liquids are compressed to a certain extent; that is, changes in pressure or temperature cause changes in density. However, in many situations, changes in pressure and temperature are small enough that the density changes are insignificant. In this case, the thread can be modeled as an unstoppable stream. Otherwise, you need to use more general compressed flow equations. Mathematically, invulnerability is expressed in the fact that the density - liquid parcel does not change as the flow is moving, i.e., D d t 0 , display frac mathrm D (c) mathrm (D't'0), where D/Dt is a derivative material that is derivative. This additional limitation simplifies the guiding equations, especially when the liquid has a single density. For the flow of gases, to determine whether to use compressed or uncontrollable fluid dynamics, the amount of Mach flow is estimated. As a rough guide, the compressible effects can be ignored on Mach numbers below about 0.3. For liquids, whether the unstoppable assumption is valid depends on the properties of the liquid (in particular, the critical pressure and temperature of the liquid) and the flow conditions (how close to critical pressure becomes the actual pressure of the flow). Acoustic problems always require compression resolution, as sound waves are compression waves that include changes in the pressure and density of the environment through which they spread. Newtonian and non-Newtonian fluids flow around the air layers, all fluids viscous, which means that they have some resistance to deformation: the adjacent areas of liquid, moving at different speeds, have viscous forces on each other. The speed gradient is called voltage speed; It is size T - 1 (T-1 display). Isaac Newton showed that for many familiar fluids, such as water and air, stress due to these viscous forces is linearly associated with voltage rates. Such liquids are called Newtonian liquids. The proportionality ratio is called fluid viscosity; for Newtonian liquids, it is a liquid property that does not depend on voltage speed. Non-Newtonian fluids have more complex, non-linear stressful behavior. Subdiscipline reology describes the stress-tension behavior of fluids that include emulsion and sludge, some viscoelytic materials such as blood and some polymers, and sticky liquids such as latex, honey and lubricants. Inviscid vs Viscous against Stokes, the flow of Liquid Parcel Dynamics is described by Newton's second law. Accelerating fluid delivery is subject to inertial effects. Reynolds' number is an immeasurable amount that characterizes the magnitude of inertial effects compared to the magnitude of viscous effects. Low Reynolds (Re ≪ 1) indicates that viscous forces are very strong compared to inertial forces. In such cases, inertial forces are sometimes neglected; this flow mode is called Stokes or creeping stream. In contrast, Reynolds' high numbers (Re ≫ 1) indicate that inertial effects have a greater effect on the field of speed than viscous (frictional) effects. In large Reynolds numbers, the flow is often modeled as an unwtered stream, an approximation in which viscosity is completely ignored. Eliminating viscosity makes it easier to make navie-Stokes equations easier in euler's equation. The integration of Euler's equations along the ordering in the invisible stream provides the Bernoulli equation. When, in addition to inviscid, the flow is irrotational everywhere, Bernoulli's equation can fully describe the flow of the world. Such streams are called potential streams because the velocity field can be expressed as a gradient of potential energy expression. This idea can work pretty well when Reynolds' numbers are high. However, problems such as problem-solving boundaries may require the inclusion of viscosity. The viscosity cannot be neglected near solid borders, because without sliding the condition generates a thin area of high voltage speed, a boundary layer in which viscosity effects dominate and which thus generates vortex. Therefore, to calculate pure forces on bodies (such as wings) it is necessary to use equations of viscous flow: the theory of the invisible flow can not predict the forces of resistance, a limitation known as the paradox of d'Alembert. The widely used citation model, especially in the dynamics of computational fluid, is to use two models of flow: Euler equations away from the body and boundary equations in a region close to the body. These two solutions can then be counseled with each other using the method of attractive asymptomatic extensions. Sustained against the unsustainable flow of Hydrodynamics simulation instability is Reilly-Taylor, a stream that is not a function of time called a steady flow. A stable flow state refers to a condition in which the properties of the liquid at the point in the system do not change over time. Time-dependent flow is known as unstable (also called transient). Whether a particular flow is stable or unsustainable may depend on the candidate frame. For example, the laminar flow over the sphere is stable within the frame of the countdown, which is stationary in relation to the sphere. In the frame of reference, which is stationary in relation to the background flow, the flow is unsteady. Turbulent flows are unsteady by definition. A turbulent stream, however, can be statistically stationary. Random U speed field (x, t) (displaystyle U(x,t) - statistically stationary if all statistics are non-variant shift in time. This roughly means that all statistical properties are permanent over time. Often the middle field is the object of the and it's also constantly in a statistically still flow. Sustainable flows are often more uropriable than similar unstable flows. The steering equations of a sustainable problem have one dimension less (time) than the guiding equations of the same problem, without taking advantage of the stability of the flow field. Laminar vs. turbulent flow of turbulence flow is characterized by recycling, vortices, and apparent randomness. A stream in which turbulence does not manifest itself is called laminar. The presence of vortexes or recycling does not necessarily indicate a turbulent flow - these phenomena may also be present in the laminar stream. A mathematically turbulent stream is often represented through Reynolds' decomposition, in which the thread is broken down to the sum of the average component and the perturbation component. It is believed that the turbulent streams can be well described with the Navier-Stokes equations. Direct numerical modeling (DNS), based on the Navier-Stokes equations, simulates turbulent flows at Reynolds' moderate numbers. Limitations depend on the power of the computer used and the effectiveness of the solution algorithm. The DNS results were found to be well consistent with experimental data for some threads. Most streams of interest have Reynolds numbers too high for DNS to be a viable option, given the state of computing power over the next few decades. Any aircraft large enough to carry a human (L'gt; 3 m) moving faster than 20 m/s (72 km/h) far goes beyond DNS (Re 4 million) simulations. The wings of transport aircraft (e.g. on the Airbus A300 or Boeing 747) have Reynolds numbers of 40 million (based on wing chord measurement). Solving these real flow problems requires a model of turbulence for the foreseeable future. Navier-Stokes equations (RANS), combined with the simulation of turbulence on average in Reynolds, are a model of the effects of turbulent flow. This simulation basically provides additional momentum transmission from Reynolds' stress, although turbulence also enhances heat and mass transmission. Another promising methodology is large Eddie Modeling (LES), especially under the guise of a separate eddy-modeling (DES), which is a combination of RANS turbulence simulation and large eddy modeling. Subsonic versus transonic, supersonic and hypersonic flows While many streams (e.g. flow of water through the pipe) occur at low Mach numbers, many streams of practical interest in aerodynamics or in turbo machines occur on high proportions of M-1 (transonic streams) or over it (super-sonic streams). waves for supersonic flow or non-equilibrium chemical behavior due to the ionization of hypersonic streams. In practice, each of these flow modes is treated separately. Separately. against non-reactive streams, Jet streams are streams, which are chemically reactive that is used in many areas such as combustion (IC engine), propulsion devices (rockets, jet engines, etc.), detonation, fire and safety threats, astrophysics, etc. Magnetohydrodynamics Main article: Magnetohydrodynamics Magnetohydrodynamics is an interdisciplinary study of the flow of electrically conductive liquids in electromagnetic fields. Examples of such liquids are plasma, liquid metals and salt water. Fluid flow equations are solved at the same time as Maxwell's electromagnetism equations. The relative fluid dynamics Relativistic fluid dynamics study the macroscopic and microscopic movement of the liquid at high speeds comparable to the speed of light. This branch of fluid dynamics explains the relativistic effects from both the special theory of relativity and the general theory of relativity. The guiding equations are derived in Riemannian geometry for Minkowski's space-time. Other approximations there are a large number of other possible approximations to fluid dynamic problems. Some of the most commonly used are listed below. The approach of Boussinesq ignores fluctuations in density, except for calculating buoyancy forces. It is often used in free convection problems where density changes are small. The Grease theory and Hele-Shaw thread uses a large ratio of domain aspects to show that certain terms in equations are small and therefore can be ignored. Slender body theory is a methodology used in runoff problems to assess strength on a long thin object in a viscous liquid or the flow field around it. Fine water equations can be used to describe a layer of relatively invisible liquid with a free surface in which surface gradients are small. Darcy's Law is used to flow into porous media, and works with variables on average for a few pores of width. In rotating systems, quasi-regophtricic equations offer an almost perfect balance between pressure gradients and Coriolis force. This is useful when studying the dynamics of the atmosphere. The terminology of the Concept of Pressure is central to the study of both liquid static and fluid dynamics. Pressure can be determined for each point in the body fluid, regardless of whether the liquid is in motion or not. Pressure can be measured using aneroide, burdon tube, mercury column or various other methods. Some of the terms required fluid dynamics are not found in other similar areas of the study. In particular, some of the terms used in the not used in liquid statics. The terminology in the irrepressible dynamics of the liquid concepts of general pressure and dynamic pressure arise from the Bernoulli equation and are important in the study of all fluid flows. (These two pressures are not pressure in the usual sense - they cannot be measured by aneroid, bourdon tube or mercury column.) To avoid potential ambiguity when it comes to pressure in fluid dynamics, many authors use the term static pressure to distinguish it from total pressure and dynamic pressure. The static pressure is identical to pressure and can be identified for each point in the fluid flow field. Of particular importance is the point in the flow of liquid, where the stream has come to rest (i.e. the speed is zero, adjacent to some solid body, immersed in the flow of liquid). It has such a meaning that it is given a special name - a point of stagnation. Static pressure at the point of stagnation is of particular importance and has its own name - the pressure of stagnation. In unstoppable streams, the pressure of stagnation at a point of stagnation equals the overall pressure throughout the field flow. The terminology in the dynamics of compressed liquid in compressed liquid, it is convenient to determine the general conditions (also called stagnation conditions) for all thermodynamic properties of the state (e.g., total temperature, total enthalpy, total speed of sound). These general flow conditions are a fluid speed function and have different values within the countdown with different movements. To avoid potential ambiguity, when it comes to the properties of liquid associated with the condition of the liquid, rather than its movement, the set-top box static (e.g. static temperature, static enthalpy) is usually used. Where there is no prefix, the property of the liquid is a static state (i.e. density and static density mean the same thing). Static conditions do not depend on the frame of reference. Since the general conditions of the flow are determined by the isentropic bringing of the liquid to rest, there is no need to distinguish between the general entropy and static entropy, as they are always equal by definition. Thus, entropy is most often referred to simply as entropy. See also Fields Research Acoustic Theory Aerodynamics Aerodynamics Computer Dynamics Fluid Measuring Geophysical Dynamics Fluid Hemodynamics Hydrology Hydrology Electrostatics Electrohydrodynamics Magnetohydrodynamics Metafluid Dynamics quantum hydrodynamics Mathematical equations and the concept of The Theory of Air Waves Benjamin-Bona-Mahony equation Bousinesq approx(water waves) Different types of boundary conditions in the fluid dynamics of Helmholtz theorem Kirchhoff equation Knudsen equation Manning equation Soft slope equation Morison equation Navier-Stokes equation Osin Flow Poise law Pressure chapter Relativist Stokes equation flow function function Simplifies streaklines and pathlines Torricelli Law Fluid Flow Types Aerodynamic Force Cavitation Condensed Flow Couette Stream Effusive Limit Free Molecular Flow Unstoppable Flow Unafstical Flow Isotermal Stream Open Stream Stream Flow Pipe Flow Secondary Stream Flow Traction Traction Averaging The Secretidity Transitional Flow Of Two-Step Flow Fluid Properties List of Hydrodynamic Instability of Newtonian Liquid Nevutonic Liquid Surface Tension Vapors Liquid Phenomena Balanced Flow Border Layer Coanda Effect Convection Cells Convergence / Bifurcation Darwin Drift Drag (Force) Droplet Evaporation Hydrodynamic Stability Kaie Effect Lift (Force) Magnus Effect Ocean Current Ocean Surface Waves Rossby Wave Shock Wave Soliton Stokes Drift Flow Turbulent Decay Jet Upstream Pollution Venturi Effect Vortex Water Hammer Wave Drag Wind Applications Aerodynamics Aerodynamics Cryosphere Science Fluidics fluid power Geodynamics Hydraulic machinery Meteorology Naval Architecture Plasma physics Pneumatics 3D computer graphics Fluid Dynamics magazines Annual Review of liquid mechanics mechanics fluid fluid mechanics Experiments in liquids European journal Mechanics B : Fluids Theoretical and Computational Fluid Dynamics Computers and Fluid International Journal for numerical techniques in fluids flow, turbulence and combustion Various important publications in the dynamics of liquid Isosurface Keulegan-Carpenter number Rotating tank Sound Barrier Beta Barrier Beta Plane Submerged Boundary Method Bridge scour the final volume method for the unstable flow See also Aileron - Surface control of the aircraft is used for inducing the aircraft roll besides the flat principle of Bernoulli - Concerns the pressure and flow speed in the dynamics of the liquid Bilgeboard Boomerang - Abandoned tool and weapon Centerboard chord (aircraft) Circulation control wing - High lifting aircraft device Currentology - Science, which studies the internal movements of the water masses Diving plane Downforce Drag ratio - Bezmer Fin Fluid Resistance Quantification - Flipper Surface Flight Control (Anatomy) - Flattened limbs adapted for movement and maneuvering in water flow of foil separation (fluid mechanics) liquid communication gas kinetics Hydrofoil - a type of rapid jet ski and the name of the technology which it uses Keel - Lower Central Structural Element of Ship or Boat Hull (Hydrodynamic) Kusner Effect Kutta State Kutta-Joukowski Theorem Lift-Induced Drag Lift-to-Drag Ratio Lifting Line Theory - Mathematical Model to quantify the rise of NACA airfoil Third Law Propeller - A device that transmits rotational power in linear traction thrust Fluid Dynamic Steering in Prowling Axis Sail (Aerodynamics) Skeg - Expanding the keel of the boat on the back, as well as the fin spoiler surfboard (car) Stall (flight) Surfboard fin surface science - Study of physical and chemical phenomena, which occur at the junction of the two stages of the Torque Converter Trim tab - Small surfaces associated with the back edge of the larger control surface on the boat is used to control the trim control wing trim - the surface used for flight, for example, insects, birds, bats and aircraft Wingtip vortex links - Eckert, Michael (2006). 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