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Topics in Shear Flow: References Consulted

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Editor's Note

These are a collection of draft files of reference lists, assembled roughly in order of the chapters of the book. The dates on the draft files range from 1996 to 1999, suggesting the author completed the major part of literature review, which began about 1986, during those years. I added a few references at the end (under "Additional References") which I found with the manuscript and which are cited therein. Many entries include the author's notes on the reference or other items to check. Numbers of draft chapter sections have been removed. An unknown number are sources the author checked but decided not to include or cite in the book. No effort has been made to identify these or place the entire list of several thousand entries in alphabetical order. The interested reader is encouraged to use a digital search by name or term of interest.
– K. Coles

Chapter 1: Introduction

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ZHANG, J., STASSINOPOULOS, D., ALSTROM, P., and LEVINSEN,

M.T. 1994 Stochastic transition intermittency in pipe flows: experiment and model. Phys. Fluids **6**, 1722–1726. *Intermittency*, figure 3. Flow rate*, figure 2. Frequency*, figure 4.*

Unsteady pipe flow

Major surveys or theory

ANDRE, P., CREFF, R., and BATINA, J. 1986 A numerical investigation of the turbulent pulsating flow in a pipe. In *Preprints, Tenth Symposium on Turbulence* (X.B. Reed, Jr. et al., eds.) Dept. Chem. Eng., Univ. Missouri (Rolla), Paper 14.

Experimental data

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LU, S.-Z., NUNGE, R.J., ERIAN, F.F., and MOHAJERY, M. 1973 Measurements of pulsating turbulent water flow in a tube. In *Turbulence in Liquids*, Univ. Missouri, Rolla, 375–393, (see also Ph. D. thesis by MOHAJERY, An experimental study of the structure of the pulsating turbulent flow of air in a circular pipe, Clarkson College of Technology, 1972). *Mean velocity*, 2 profiles, figures 3, 4. Main subject is oscillating flow.*

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SARPKAYA, T. 1966 Experimental determination of the critical Reynolds number for pulsating Poiseuille flow. Trans. ASME (J. Basic Eng.) **88**, 589–598. *Large L/D, about 1300. Disturbance generator is pin. Flow well regulated. Pressure gradient; celerity for steady case. ASME Paper 66-FE-5. Celerity*, figure 6.*

SCHULTZ-GRUNOW, F. 1940 Pulsierender Durchfluss durch Rohre. Forschung auf dem Gebiete des Ingenieurwesens **11**, 170–187 (in English as ”‘Pulsating flow through pipes,” NASA Technical Translation NASA TT F-14,881, 1973). *Friction*, figure 6. Mean velocity*, figures 7, 10. Reynolds stresses*, figures 21, 22.*

SHEMER, L. and WYGNANSKI, I. 1981 On the pulsating flow in a pipe. In: *Preprints, 3rd Symposium on Turbulent Shear Flows*, Univ. California (Davis), 8.13–8.18. *Velocity traces*, figure 5. Reynolds stresses, figure 6.*

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STETTLER, J.C. and HUSSAIN, A.K.M.F. 1986 On transition of the pulsatile pipe flow. J. Fluid Mech. **170**, 169–197. *Small sinusoidal perturbation of mean flow. LDA instrumentation. Poiseuille profile measured as check. Laminar profile*, figure 1. Intermittency frequency*, figure 4.*

TU, S.W. and RAMAPRIAN, B.R. 1983 Fully developed periodic turbulent pipe flow. Part 1. Main experimental results and comparison with predictions. J. Fluid Mech. **137**, 31–58. *Four profiles of mean velocity in steady flow. Mean velocity*, figures 3, 4, 5, 10. Reynolds stresses*, figures 6, 11, 13.*

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Dept. Eng. Mechanics, Univ. Illinois, 1964). *Fig. 2 includes photo of slug. Fig. 10, 15 is celerity of front, rear. Fig. 13, 16 is intermittency. Intermittency*, figure 4. Little on steady flow; mostly on relaxation time.*

Area change in pipe flow

Major surveys or theory

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SULTANIAN, B.K., NEITZEL, G.P., and METZGER, D.E. 1987 Turbulent flow prediction in a sudden axisymmetric expansion. In *Turbulence Measurements and Flow Modeling* (C.J. Chen et al., eds.), Hemisphere, 655–664.

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Experimental data

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BACK, L.H. and ROSCHKE, E.J. 1972 Shear-layer regimes and wave instabilities and reattachment lengths down-stream of an abrupt circular channel expansion. Trans. ASME (J. Appl. Mech. **39E**), 677–681. *Reattachment*, figure 1. Flow viz*, figure 3.*

BENEDICT, R.P., CARLUCCI, N.A., and SWETZ, S.D. 1966 Flow losses in abrupt enlargements and contractions. Trans. ASME (J. Eng. Power) **88A**, 73–81. *Loss coefficients*, figures 7–10.*

BOGER, D.V. and HALMOS, A.L. 1974 Accelerating and deaccelerating flows of viscoelastic fluids. In *Proc. Fifth Australasian Conference Hydraulics and Fluid Mechanics*, Vol. I, 403–410. *Laminar. Mean velocity, figure 5. Reattachment length, figures 1, 2. Centerline velocity, figure 6.*

BRIGHTMORE, A.W. 1907 Loss of pressure in water flowing through straight and curved pipes. Minutes of Proceedings of the Institution of Civil Engineers **169**, 315–336.

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DEVENPORT, W.J. and SUTTON, E.P. 1993 An experimental study of two flows through an axisymmetric sudden expansion. Experiments in Fluids **14**, 423–432. *Survey*, table 1. Velocity*, figures 3, 4. Geometry*, figure 2.*

DUDGEON, C.R. and HILLS, J.E. 1986 Head losses in pipe fittings with stepped contractions and expansions. In *Proc. 9th Australasian Fluid Mechanics Conference*, Auckland, 105–108. *Pressure gradient*, figure 3.*

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GIBSON, A.H. 1910 On the flow of water through pipes and passages having converging or diverging boundaries. Proc. Roy. Soc. London **83A**, 366–378. *Pressure distribution only. Tapered pipes, including sudden enlargement.*

GOULD, R.D., STEVENSON, W.H., and THOMPSON, H.D. 1986 Experimental and computational investigation of turbulent transport in an axisymmetric sudden expansion. In *Preprints, Tenth Symposium on Turbulence* (X.B. Reed, Jr. et al., eds.), Dept. Chem. Eng., Univ. Missouri (Rolla), Paper 36. *Geometry*, figure 2. Mean velocity*, figures 3, 4. Reynolds stresses*, figures 5-7. Energy balance.*

GOULD, R.D., STEVENSON, W.H., and THOMPSON, H.D. 1990 Investigation of turbulent transport in an axisymmetric sudden expansion. AIAA J. **28**, 276–283. *Smooth nozzle into tube. Profiles of mean velocity, Reynolds stresses. Mean velocity*, figures 3, 4. Reynolds stresses, figures 5–8.*

HA MINH, H. and CHASSAING, P. 1979 Perturbations of turbulent pipe flow. In *Turbulent Shear Flows 1* (F. Durst *et al.*, eds.), Springer-Verlag, 178–197. *Velocity*, figures 8, 9, 10. Reynolds stresses*, figures 11, 12. Energy balance.*

KALINSKE, A.A. 1946 Conversion of kinetic to potential energy in flow expansions. Trans. ASCE **111**, 355–374 (discussion 375–390). *Conical diffusers. Velocity from particles. Abrupt expansion*, figure 5. Also diffusers.*

KHEZZAR, L. and WHITELAW, J.H. 1988 Flows through round sudden contractions. Proc. Inst'n. Mech. Engrs. **202C**, 295–300. *Geometry*, figure 1. Mean velocity*, Reynolds stresses*, figures 3, 4.*

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KHEZZAR, L., WHITELAW, J.H., and YIANNESKIS, M. 1986 Round sudden-expansion flows. Proc. Inst'n. Mech. Engrs. **200C**, 447–455. *Reattachment*, figure 1. Mean velocity*, Reynolds stresses*, figures 3, 4, 5. Pressure*, figure 6.*

KRALL, K.M. 1965 Turbulent heat transfer in the separated, reattached, and redevelopment regions of a tube. M.S. thesis, University of Minnesota. *Heat transfer only. Good on relaxation. Data are tabulated.*

LAVAN, Z. and SHAVIT, G. 1971 Recirculation patterns in confined laminar jet mixing. Israel J. Technology **9**, 51–60. *Geometry*, figure 1. Streamlines*, figures 2–4. Pressure*, figure 6.*

LISSENBURG, R.C.D., HINZE, J.O., and LEIJDENS, H. 1975 An experimental investigation of the effect of a constriction on turbulent pipe flow. Appl. Sci. Res. **31**, 343–362 (also Technische Hogeschool Delft, Rep. WTHD 76, 1975).

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MACAGNO, E.O. and HUNG, T.-K. 1967 Computational and experimental study of a captive annular eddy. J. Fluid Mech. **28**, 43–64, 3 plates. *Geometry*, figure 1. Streamlines*, figures 3, 4, 5. Flow viz*, figure 8.*

MOON, L.F. and RUDINGER, G. 1977 Velocity distribution in an abruptly expanding circular duct. Trans. ASME (J. Fluids Eng.) **99**, 226–230. *Re to 400,000. Probably not fully developed flow. Mean velocity*, figure 3. Reattachment length*, figure 2.*

ROSCHKE, E.J. and BACK, L.H. 1976 The influence of upstream conditions on flow reattachment lengths downstream of an abrupt circular channel expansion. J. Biomechanics **9**, 481–483. *Initial profile is uniform.*

Large range of Re. See parent paper. Reattachment, figure 1.*

SHEN, X., DING, Q., YU, J., and WANG, H. 1991 LDV measurement of flow through an axisymmetrical constriction with a core rod. In *Recent Advances in Experimental Fluid Mechanics* (F.G. Zhuang, ed.), International Academic Publishers, 425–429. *Velocity*, figure 2. Reynolds stresses*, figure 3.*

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SULLIVAN, P. and GLAUSER, M. 1990 LDA measurements in a sudden expansion. In *Engineering Turbulence Modelling and Experiments* (W. Rodi and E.N. Ganic, eds.), Elsevier, 727–736. *Table 1*. Mean velocity*, figure 3.*

VALLETTE, P., LEBOUCHÉ, M., and MARTIN, M. 1979 Étude spatio-temporelle de la réorganisation d'un écoulement en aval d'un élargissement brusque. J. Mécanique Appliquée **3**, 389–410. *Mean velocity*, figure 7. Wall stress*, figure 10. This is thesis by Lebouché.*

Pipe flow with suction or blowing

Major surveys or theory

Experimental data

BROSH, A. and WINOGRAD, Y. 1974 Experimental study of turbulent flow in a tube with wall suction. Trans. ASME (J. Heat Transf.) **96C**, 338-342. *Local or distributed suction. Profiles of mean velocity, rms* u'. *Mean velocity*, figures 2, 3, 5, 6. Reynolds stresses*, figures 2, 3, 5, 6, 7.*

ELENA, M. 1977 Étude expérimentale de la turbulence au voisinage de la paroi d'un tube legerement chauffe. Int'l. J. Heat Mass Transf. **20**, 935-944 (see also thesis by ELENA, Étude des structures dynamiques et thermiques d'un écoulement turbulent en conduit avec aspiration a la paroi. Univ. Aix-Marseille, 1975; also Commissariat a l'Energie Atomique, Rep. CEA-R-4843; also M. Elena and R. Dumas, Turbulence scales in a pipe flow with a slightly heated wall, ASME Paper 78-HT-4, 1978). See 3A p 19. *Reynolds stresses, figure 4. No translation. Thesis at Marseilles, 1975.*

Pressure, figure 4.1. Mean velocity*, figures 4.3, 4.9. Mean temperature*, figures 4.4, 4.11. Reynolds stresses*, figures 4.23–4.24.*

HEDLIN, C.P. 1957 An investigation of the influence of the presence of vapor diffusing from a wetted non-adiabatic boundary upon the sensible heat transfer between a boundary wall and a gas stream. Ph. D. thesis, Dept. Mech. Eng., Univ. Toronto. *Heat transfer*, figure 5. Data are tabulated.*

HUESMANN, K. and Eckert, E.R.G. 1968 Untersuchungen über die laminare Strömung und den Umschlag zur Turbulenz in porösen Rohren mit gleichmässiger Einblasung durch die Rohrwand. Wärme und Stoffübertragung **1**, 2–9. *Mean velocity*, figures 4, 5, 7–10. Pressure, figure 12.*

LIN, C.S., MOULTON, R.W., and PUTNAM, G.L. 1953 Mass transfer between solid wall and fluid streams. Ind. Eng. Chem. **45**, 636–646. *Interferometric data on concentration. Power law at wall. Uses Karman buffer layer. Concentration*, figures 5, 6.*

LINTON, W.H. JR. and SHERWOOD, T.K. 1950 Mass transfer from solid shapes to water in streamline and turbulent flow. Chem. Eng. Progress **46**, 258–264. *Mass transfer*, figures 5–7.*

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PENNELL, W.T., SPARROW, E.M., and ECKERT, E.R.G. 1972 Turbulence intensity and time-mean velocity distributions in low Reynolds number turbulent pipe flows. Int'l. J. Heat Mass Transf. **15**, 1067-1074 (see also Ph.D. thesis by PENNELL, The effect of uniform mass injection on the structure of turbulent flow through a porous pipe, Univ. Minnesota, 1970). *Mean velocity, figures 4.1, 4.2. Centerline turbulence*, figure 4.3. Reynolds stresses*, figures 4.4, 4.6-4.11. No tables. Note data with injection at wall.*

SCHILDKNECHT, M., MILLER, J.A., and MEIER, G.E.A. 1979 The influence of suction on the structure of turbulence in fully developed pipe flow. J. Fluid Mech. **90**, 67-107. (Preliminary version, same authors, is "The influence of suction on energy distribution in fully established turbulent pipe flow," in *Turbulence in Liquids*, Univ. Missouri, Rolla, 56-62, 1975. See also Schildknecht, "Experimente zum Einfluss von Absaugung auf eine ausgebildete turbulente Rohrströmung," Bericht 106/1979, Max-Planck-Institut für Strömungsforschung, Göttingen, 1979.) *Mean velocity*, one profile, figure 3. Reynolds stresses*, figures 4-7. Energy balance. Mostly* *on effects of suction.*

WEISSBERG, H.L. and BERMAN, A.S. 1955 Velocity and pressure distributions in turbulent pipe flow with uniform wall suction. In *Proc. Heat Transfer and Fluid Mechanics Institute*, Los Angeles, Paper XIV (see also Ph.D. thesis by WEISSBERG, same title, Univ. Tennessee, 1954). *Solid wall: mean velocity*, figures 17, 18, 25-32, 45. Reynolds stresses, figures 21, 22, 33-40, 47. Data are tabulated. Mostly suction, but includes turbulent development length.*

YUAN, S.W. and BARAZOTTI, A. 1958 Experimental investigation of turbulent pipe flow with coolant injection. In *Proc. Heat Transfer and Fluid Mechanics Institute*, 25–39 (see also, same authors, "Experimental investigation of transpiration cooling in turbulent pipe flow," Dept. Aeron. Eng. Appl. Mech., Polytechnic Inst. Brooklyn, PIBAL Rep. 479. *Mean velocity*, figure 2. With injection*, figures 5, 6. Mean temperature, figures 7, 11.*

Pipe flow of liquid metals

Major surveys or theory

LYKOUDIS, P.S. and TOULOUKIAN, Y.S. 1958 Heat transfer in liquid metals. Trans. ASME **80**, 653–663 (discussion, 663–666). *Fully developed pipe flow. See for experimental refs.*

MARTINELLI, R.C. 1947 Heat transfer to molten metals. Trans. ASME **69**, 947–956 (discussion, 956–959). *Theory, mostly effect of Pr.*

Experimental data

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EYLER, L.L. 1978 Turbulent structure measurements and thermal transport modeling in liquid metals. Ph.D. thesis, Purdue Univ. *Adiabatic: mean velocity, figure 5-1, tables I-1, I-2.*

FLAHERTY, T.W. 1974 An investigation of non-isothermal turbulent pipe flow of mercury. Ph. D. thesis, Purdue Univ. *Mean velocity*, figure VI-1, VI-2. Friction*, figure VI-3. Mean temperature*, figure VI-5. Heavy on spectra. Some data tabulated.*

HOCHREITER, L.E. 1971 Turbulent structure of isothermal and non-isothermal liquid metal pipe flow. Ph.D. thesis, Purdue Univ. *Adiabatic: friction coefficient, figures 16, 18. Mean velocity, figure 17, tables G2–G7. Reynolds stresses, figures 40–45, tables G20–G24.*

HOFFMAN, H.W. 1953 Turbulent forced convection heat transfer in circular tubes containing molten sodium hydroxide. In *Proc. Heat Transfer and Fluid Mechanics Institute*, 83–96. *Wall temperature*, figure 3. Heat transfer*, figure 7.*

ISAKOFF, S.E. and DREW, T.B. 1951 Heat and momentum transfer in turbulent flow of mercury. In *Proc. General Discussion on Heat Transfer*, Inst'n. Mech. Eng., London, 405–409 (see also Ph.D. thesis by ISAKOFF, same title, Columbia Univ., 1952). *Isothermal: mean velocity, 10 profiles, figures 17–27, tables p 155-164. Friction coefficient, table p 175. Max/mean velocity, figure 33.*

High temperature

Major surveys or theory

Experimental data

EVANS, S.I. and SARJANT, R.J. 1951 Heat transfer and turbulence in gases flowing inside tubes. J. Inst. Fuel **24**, 216–227. *Very high temperatures. Heat transfer*, figure 10.*

PERKINS, H.C. and WORSOE-SCHMIDT, P. 1965 Turbulent heat and momentum transfer for gases in a circular tube at wall to bulk temperature ratios to seven. Int'l. J. Heat Mass Transf. **8**, 1011–1031. *Friction coefficient, figures 3, 5, 6, 13. Nusselt number, figures 9–13. Data are tabulated.*

Non-circular pipes

Major surveys or theory

DEMUREN, A.O. and RODI, W. 1984 Calculation of turbulence-driven secondary motion in non-circular ducts. J. Fluid Mech. **140**, 189–222. *Isotachs*, figures 1, 15.*

EMERY, A.F., NEIGHBORS, P.K., and GESSNER, F.B. 1980 The numerical prediction of developing turbulent heat transfer in a square duct. Trans. ASME (J. Heat Transfer) **102**, 51–57. *Geometry*, figure 1. Isotachs*, figure 4. Secondary flow*, figure 5. Wall friction*, figure 6. Flow development, figure 10.*

HUSER, A. and BIRINGEN, S. 1993 Direct numerical simulation of turbulent flow in a square duct. J. Fluid Mech. **257**, 65–95. *Isotachs*, secondary flow*, figure 4. Velocity*, figure 6.*

HUSER, A., BIRINGEN, S., and HATAY, F.F. 1994 Direct simulation of turbulent flow in a square duct: Reynolds-stress budgets. Phys. Fluids **6**, 3144–3152. *Energy budgets, figures 1–5.*

LOHRENZ, J. and KURATA, F. 1960 A friction factor plot for smooth circular conduits, concentric annuli, and parallel plates. Ind. Eng. Chem. **52**, 703–706.

McCOMAS, S.T. 1967 Hydrodynamic entrance lengths for ducts of arbitrary cross section. Trans. ASME (J. Basic Eng.) **89**, 847–850. *Integral method. Development length for annular, elliptic, rectangular, triangular ducts.*

PERRY, A.E. 1964 The concept of hydraulic diameter. ASME Paper 64-WA/FE-31.

Experimental data

BRIGHTON, J.A. and JONES, J.B. 1964 Fully developed turbulent flow in annuli. Trans. ASME (J. Basic. Eng.) **86D**, 835–842 (discussion 842–844) (see also Ph. D. thesis by BRIGHTON, The structure of fully developed turbulent flow in annuli, Dept. Mech. Eng., Purdue Univ., 1963). *Friction coefficient, figure 2. Mean velocity, figures 6–9. Reynolds stresses, figures 11, 12, 14.*

BRUNDRETT, E. and BAINES, W.D. 1964 The production and diffusion of vorticity in duct flow. J. Fluid Mech. **19**, 375–394. *Square, rectangular, trapezoidal ducts. All results faired.*

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KHALIFA, M.M.A. and TRUPP, A.C. 1986 Measurements of fully developed turbulent flow in a trapezoidal duct. In *Preprints, Tenth Symposium on Turbulence* (X.B. Reed, Jr. et al., eds.), Dept. Chem. Eng., Univ. Missouri (Rolla), Paper 37. *Friction coefficient*, figures 2, 8. Mean velocity*, figure 7. Reynolds stresses, figure 9.*

KIND, R.J., YOWAKIM, F.M., and SJOLANDER, S.A. 1989 The law of the wall for swirling flow in annular ducts. Trans. ASME (J. Fluids Eng.) **111**, 160–164. *Wall law*, figures 2, 3, 5.*

KNIGHT, D.W. and LAI, C.J. 1987 Turbulent flow in compound channels and ducts. In *Turbulence Measurements and Flow Modeling* (C.J. Chen et al., eds.), Hemisphere, 697–706. *Geometry*, figure 1. Velocity*, figures 3–13.*

LAUNDER, B.E. and YING, W.M. 1972 Secondary flows in ducts of square cross-section. J. Fluid Mech. **54**, 289–295. *Also Rep. TM/TN/A/ll, Dept. Mech. Eng., Imperial College, 1971. Velocity*, figure 5. isotachs*, figure 6.*

LOWDERMILK, W.H., WEILAND, W.F. Jr., and LIVINGOOD, J.N.B. 1954 Measurement of heat-transfer and friction coefficients for flow of air in noncircular ducts at high surface temperatures. NACA RM E53J07. *Nusselt number. Square, rectangular, triangular ducts.*

NIKURADSE, J. 1926 Untersuchungen über die Geschwindigkeitsverteilung in turbulenten Strömungen. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, Verein deutscher Ingenieure, Heft 281. *This is N's thesis. Rectangular and triangular ducts, also channel with free surface. Mean velocity, figures 7–13.*

NIKURADSE, J. 1930 Untersuchungen über turbulente Strömungen in nicht kreisförmigen Rohren. Ing.-Arch. **1**, 306–332. *Triangle, trapezoid, circle with key, etc. Nice data.*

OBOT, N.T. and ADU-WUSU, K. 1987 Pressure drop, velocity and heat transfer characteristics in smooth scalene triangular ducts having two rounded corners. In Turbulence Measurements and Flow Modeling (C.J. Chen et al., eds.), Hemisphere, 687–695. *Friction*, figure 2. Velocity*, figures 3–5.*

RODET, É. 1960 Étude de l'écoulement d'un fluide dans un tunnel prismatique de section trapézoïdale. Publications Scientifiques et Techniques du Ministere de l'Air, Paris, No. 369. *Mean velocity, figures 5–10. Reynolds stresses, figures 11-14, 17, 18. Nice work but out of main stream.*

Pipe flow with swirl

Major surveys or theory

KURODA, C. and OGAWA, K. 1986 Turbulent swirling pipe flow. In *Encyclopedia of Fluid Mechanics*, Vol. 1, Flow Phenomena and Measurement (N.P. Cheremisinoff, ed.), 611–637. *(Chapter 20).*

ORLANDI, P. 1997 Helicity fluctuations and turbulent energy production in rotating and non-rotating pipes. Phys. Fluid **9**, 2045–2056.

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Chapter 3: Channel Flow

Flow in smooth channel

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Flow in rough channel

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Chapter 4: The Boundary Layer

Boundary layers

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Equilibrium boundary layer

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Boundary layer with pressure gradient

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TENNEKES, H. 1964 Comment on "Velocity defect law for a transpired turbulent boundary layer." AIAA J. **2**, 414–415, with reply by Mickley and Smith. *Comment on Mickley and Smith, AIAA J.* **1***, p 1685; Tennekes identifies his w^* with friction velocity based on τ_{max}; suggests wall law $(\rho v_w u)/\tau_w = f(y v_w/\nu)$ as in laminar flow. Reply says yes, τ_{max} NG for flows with suction.*

TENNEKES, H. 1965 Velocity defect laws for transpired turbulent boundary layers. AIAA J. **3**, 1950–1951. *On Mickley vs Stevenson; assumes both defect laws valid; linearizes $\emptyset^+$ defect law to show (my notation) except for asymptotic suction; w^* and $(\tau_{\max}/\rho)^{\frac{1}{2}}$ nearly interchangeable.*

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reacting (H.E. Weber, ed.), ASME, 145–151.

Experimental data

AL SAJI, S.J. 1968 The transpired turbulent boundary layer with heat transfer. Ph. D. thesis, Dept. Mech. Eng., Univ. Utah. *Boundary layer with blowing. Profiles of mean velocity, turbulence intensity. Flow probably 3-D or suffering from effects of trip (2 feet of sandpaper). Mean velocity*, figures 6, 9, 11, 16, 23, 29–31. Friction*, figures 10, 38. Reynolds stresses*, figures 26, 28, 45–47, 51, 52. Also heat transfer. Data are tabulated.*

ALBERTSON, M.L. 1948 Analysis of evaporation as a boundary-layer phenomenon. Ph. D. thesis, State Univ. Iowa; see also "Evaporation from a plane boundary", *Proc. 1951 Heat Transfer Fluid Mechanics Institute*, 243–254. *Local evaporation of water from small porous porcelain surface; hot-wire profiles of mean velocity. May be useful as "porous element" calibration. Mean velocity*, figures 6, 7, 8.*

ANDERSON, P.S., KAYS, W.M., and MOFFAT, R.J. 1972 The turbulent boundary layer on a porous plate: an experimental study of the fluid mechanics for adverse free-stream pressure gradients. Dept. Mech. Eng., Stanford Univ., Rep. No. HMT-15 (see also same authors, "Experimental results for the transpired turbulent boundary layer in an adverse pressure gradient", J. Fluid Mech. **69**, 353–375, 1975). *Sintered porous plate. Suction and blowing with adverse pressure gradient. Profiles of mean velocity, shearing stress (tabulated); a few profiles of u', v', w' (not tabulated). JFM does not include $dp/dx = 0$, $m = 0$. Friction*, figures 6.1, 6.2. Reynolds stresses*, figures 6.10, 6.20–6.46. Mean velocity, figures 6.14, 6.15. Data are tabulated.* **Case 241, 242, 1980 Stanford contest.**

ANTONIA, R.A. and ZHU, Y. 1995 Effect of concentrated wall suction on a turbulent boundary layer. Phys. Fluids **7**, 2465–2474. *Geometry*, figure 1. Friction*, figure 3. Velocity*, figure 10. Reynolds stresses*, figures 11–13.*

ANTONIA, R.A., FULACHIER, L., KRISHNAMOORTHY, L.V., BENABID, T., and ANSELMET, F. 1988 Influence of wall suction on the organized motion in a turbulent boundary layer. J. Fluid Mech. **190**, 217–240. *Reynolds stresses*, figure 2.*

BAKER, R.J. and LAUNDER, B.E. 1974 The turbulent boundary layer with foreign gas injection. I. Measurements in zero pressure gradient. Int'l. J. Heat Mass Transfer **17**, 275–291. *Velocity*, figures 4, 6, 10, 16–18. Friction*, figures 5, 7.*

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BLACKWELL, B.F. 1972 The turbulent boundary layer on a porous plate: an experimental study of the heat transfer behavior with adverse pressure gradients. Ph. D. thesis, Dept. Mech. Eng., Stanford Univ.; also Rep. No. HMT-16, with W.M. Kays and R.J. Moffat. *Stanton number*, figures 4.1–4.3. Mean temperature*, figures 5.1–5.8. Data are tabulated.*

BUTENSKY, M.S. 1962 The transpired turbulent boundary layer on a flat plate. Sc. D. thesis, Dept. Chem. Eng., MIT. *One flow with moderate blowing, air into air; profiles of mean velocity, three turbulent stresses; all data tabulated in thesis. Suggests friction velocity based on* τ_{max}. *Tunnel cleaned since Smith used it. Mean velocity*, figures 11, 15, 23. Friction*, figures 17, 18. Reynolds stresses*, figures 20, 27, 32, 33. Data are tabulated; do not agree with Smith.*

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CHOE, H. 1975 The turbulent boundary layer on a full-coverage film-cooled surface: an experimental heat transfer study with normal injection. Ph. D. thesis, Dept. Mech. Eng., Stanford Univ.; also Rep. No. HMT-22, with W.M. Kays and R.J. Moffat. *Stanton number*, various. Mean velocity*, mean temperature, various. Data are tabulated.*

CICCONE, A.D., KAWALL, J.G., and KEFFER, J.F. 1989 On the determination of particle-erosion rates within a turbulent boundary layer. In *Preprints, Seventh Symposium on Turbulent Shear Flows*, Stanford Univ., Paper 15-4. *Saltation and erosion. This is Ph. D. thesis by Ciccone, U. Toronto, 1988.*

CLARK, H. III and Deutsch, S. 1991 Microbubble skin friction reduction on an axisymmetric body under the influence of applied axial pressure gradients. Phys. Fluids **A3**, 2948–2954. *Velocity*, figure 4. Drag*, figures 5, 8, 9.*

CRAWFORD, M.E., CHOE, H., KAYS, W.M., and MOFFAT, R.J. 1975 Full-coverage film cooling heat transfer studies – a summary of the data for normal-hole injection and 30° slant-hole injection. Stanford Univ., Dept. Mech. Eng., Rep. HMT-19. *Summary and comparison of results from theses by Choe and Crawford. Geometry*, figures 1, 2. Heat transfer*,* *figures 9–11, 13, 16, 17, 20, 22–24 and more.*

CRAWFORD, M.E., KAYS, W.M., and MOFFAT, R.J. 1976 Heat transfer to a full-coverage film-cooled surface with 30° slant-hole injection. Stanford Univ., Dept. Mech. Eng., Rep. No. HMT-25. *Eleven rows of holes with downstream recovery section. Velocity ratio from zero to 1.3. Stanton number; a few profiles of mean velocity and mean temperature near one hole. Geometry*, figure 2.1. Velocity*, figures 3.1, 3.5. Stanton number*, figure 3.23, 3.7. Temperature*, figures 3.27, 3.28. Data are tabulated.*

DERSHIN, H., LEONARD, C.A., and GALLAHER, W.H. 1967 Direct measurement of skin friction on a porous flat plate with mass injection. AIAA J. **5**, 1934–1939. *Geometry*, figure 1. Friction balance*, figure 4. Surface friction*, figure 15.*

DUTTON, R.A. 1955 Experimental studies of the turbulent boundary layer on a flat plate with and without distributed suction. Ph. D. thesis, Univ. Cambridge (see also "The asymptotic turbulent boundary layer", J.A.S. **23**, 1127–1128, 1956. *Turbulent boundary layer with and without uniform suction (including asymptotic suction layer); profiles of mean velocity; local surface friction (Preston tube). Growth rate*, figures 11, 14. Mean velocity*, figures 17, 19, 37, 42. See several R&M's. Data are tabulated.*

FAVRE, A., DUMAS, R., and VEROLLET, E. 1961 Couche limite sur paroi plane poreuse avec aspiration. Commissariat a l'Energie Atomique, Rapp. CEA No. 1978. *Mean velocity*, figure 2. Streamlines*, figure 4. Reynolds stress*, figures 7, 8.*

FAVRE, A., DUMAS, R., VEROLLET, E., and COANTIC, M. 1966 Couche limite turbulente sur paroi poreuse avec aspiration. J. de Mécanique **5**, 3–28; see also preliminary report "Couche limite sur paroi plane poreuse avec aspiration", Commissariat a l'Energie Atomique, Rapport CEA No. 1978, 1961, by A. Favre, R. Dumas, and E. Verollet. *Suction for flow with long starting length; hot-wire profiles of mean velocity, turbulence intensity. 1961 work given at Stresa Congress; see PST 377, 1961. See CEA report.* **Case 244, 1980 Stanford Contest.**

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FULACHIER, L. 1965 Contribution a l'etude des analogies de Reynolds; ecoulement turbulent avec aspiration sur paroi chauffee. Thesis, Univ. d'Aix-Marseille; see also "Etude d'une couche limite turbulente avec aspiration et chauffage a la paroi", HERCEG-NOVI, Yugoslavia, 1968, by E.

Verollet, L. Fulachier, R. Dumas, and A. Favre. *Suction; profiles of mean velocity, mean temperature. Mean velocity*, figures 11–20, 22. Mean temperature*, figures 24–30, 32. Data are tabulated.*

FULACHIER, L., BENABID, T., ANSELMET, F., ANTONIA, R.A., and KRISHNAMOORTHY, L.V. 1987 Behaviour of coherent structures in a turbulent boundary layer with wall suction. In *Advances in Turbulence* (G. Comte-Bellot and J. Mathieu, eds.), Springer-Verlag, 399–407.

FURBER, B.N. 1954 Some heat and mass transfer experiments on humid air in turbulent flow over a plane containing an isolated cooled region. Proc. Inst'n. Mech. Eng. **168**, 847–859 (discussion, 860). *Geometry*, figure 1. Velocity*, figure 8. Heat, mass transfer*, figures 9, 10. Some data are tabulated.*

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GOLDSTEIN, R.J., ECKERT, E.R.G., and RAMSEY, J.W. 1968 Film cooling with injection through a circular hole. Univ. Minnesota, Dept. Mech. Eng., Heat Transfer Lab., Rep. HTL TR No. 82 (NASA CR-54604). *Geometry*, figure 1. Effectiveness*, figures 7–16, 18–25.*

GOODWIN, B.M. 1961 The transpired turbulent boundary layer with zero pressure gradient. Sc. D. thesis, Dept. Chem. Eng., MIT. *Reynolds stresses*, figures 1, 2. Mean velocity*, figures 6, 9–12, 15, 16. Friction, figures 7, 8, 18. Data are tabulated.*

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HALL, D. 1988 Measurements of the mean force on a particle near a boundary in turbulent flow. J. Fluid Mech. **187**, 451–466. *Lift force measured in pipe. Very nice. Force*, figures 8, 9.*

HARDY, J.K., HALES, K.C., and MANN, G. 1951 The condensation of water on refrigerated surfaces. Food Investigation Board, Dept. Sci. Indus. Res. Special Rep. No. 54. *Vertical plate with gravity flow of water film; a few profiles of mean velocity, mean temperature, and mean vapor pressure (five stations; 19.0 ft/sec?). Available from NASA. Mean velocity, temperature, concentration*, figure 4.*

HEALZER, J.M. 1974 The turbulent boundary layer on a rough, porous plate: experimental heat transfer with uniform blowing. Ph. D. thesis, Dept. Mech. Eng., Stanford Univ.; also Rep. No. HMT-18, with R.J. Moffat and W.M. Kays. *Plate fabrification. Friction, heat transfer*, figures 3.1, 3.2, 3.26. Mean velocity*, figures 3.3, 3.4. Data are tabulated.*

ISAACSON, L.K. and AL SAJI, S.J. 1969 Temperature laws for a turbulent boundary layer with injection and heat transfer. AIAA J. **7**, 157-159. *Mean temperature*, figure 3.*

JONES, J.W. and ISAACSON, L.K. 1970 A turbulent boundary layer with mass addition, combustion, and pressure gradients. College of Engineering, Univ. Utah, Rep. AFOSR 70-1428TR. *Mean velocity*, figures 14, 15. Mean temperature*, figures 16, 17. Data are tabulated.*

JONSSON, V.K. and BATTON, W.D. 1965 Hot-wire anemometer study of a turbulent boundary layer on a porous axial circular cylinder with uniform air injection. Univ. Minn., Rep. HTL-TR-65. *Mild blowing of air into air at constant pressure; profiles of mean velocity, turbulence intensity, and Reynolds shearing stress. Geometry*, figure 2. Data are tabulated.*

JULIEN, H.L. 1969 The turbulent boundary layer on a porous plate: Experimental study of the effects of a favorable pressure gradient. Ph. D. thesis, Dept. Mech. Eng., Stanford Univ.; also Rep. No. HMT-4, 1969 (with W.M. Kays and R.J. Moffat). *Accelerating flows with continuous or discontinuous suction or blowing; relaminarization; profiles of mean velocity. Mean velocity*, figures 6–9, 12–27. Reynolds stresses*, figures 31, 32. Data are tabulated.*

KAFTORI, D., HETSRONI, G., and BANERJEE, S. 1995 Particle behavior in the turbulent boundary layer. I. Motion, deposition, and entrainment. Phys. Fluids **7**, 1095–1106. *Wall profile*, figure 4. Trajectories*, figure 13.*

KAFTORI, D., HETSRONI, G., and BANERJEE, S. 1995 Particle behavior in the turbulent boundary layer. II. Velocity and distribution profiles. Phys. Fluids **7**, 1107–1121. *Mean velocity*, figure 1. Reynolds stresses*, figure 8. Concentration*, figures 12, 13, 14.*

KAY, J.M. 1953 Boundary-layer flow along a flat plate with uniform suction. ARC R&M 2628. *Plane boundary layer at constant pressure with moderate suction at surface. Mean velocity*, figures 2–10, 13–24, 29–30.*

KEARNEY, D.W. 1970 The turbulent boundary layer: Experimental heat transfer with strong favorable pressure gradients and blowing. Ph. D. thesis, Dept. Mech. Eng., Stanford Univ.; also Rep. No. HMT-12, 1970 (with R.J. Moffat and W.M. Kays). *Emphasis on relaminarization and/or effect of increased free-stream turbulence level; profiles of mean temperature (mean velocity interpolated from data of Loyd); a few profiles of turbulence intensity; Stanton numbers. Mean velocity*, mean temperature. Data are tabulated.*

KENDALL, R.M. 1959 Interaction of mass and momentum transfer in the turbulent boundary layer. Sc. D. thesis, Dept. Chem. Eng., MIT.

Five flows with moderate blowing of air with helium tracer into air; profiles of mean velocity, mean concentration; all data tabulated in thesis. Says wall not flat; 3-D effects. Mean velocity, figures 6–12, 14, 43. Wall friction*, figure 32. Mean concentration*, figures 36–40, 51. Sherwood number*, figure 42.*

KIM, H.K., MOFFAT, R.J., and KAYS, W.M. 1978 Heat transfer to a full-coverage, film-cooled surface with compound-angle (30° and 45°) hole injection. Stanford Univ., Dept. Mech. Eng., Rep. HMT-28. *Holes cover entire plate. Velocity ratio zero to 1.5. Stanton number; upstream velocity profiles. All data are tabulated.*

KULGEIN, N.G. 1962 Transport processes in a combustible turbulent boundary layer. J. Fluid Mech. **12**, 417–437. *Boundary layer on cylinder aligned with flow direction; profiles of turbulence intensity, mean concentrations, mean temperature, mean velocity. This is Harvard thesis, Div. Eng. Appl. Phys., 1960. Very large scatter.*

LAURSEN, E.M. 1957 An investigation of the total sediment load. Iowa Inst. Hydr. Res., State Univ. Iowa, Final Rep., Contract N8onr-500(02). *Mean velocity*, figures 10, 12. Mean concentration*, figure 13. Data are tabulated.*

LEGAY-DESESQUELLES, F. and PRUNET-FOCH, B. 1985 Dynamic behaviour of a boundary layer with condensation along a flat plate: comparison with suction. Int'l. J. Heat Mass Transf. **28**, 2363-2370. *Condensation of steam. Mean velocity*, figure 6.*

LEVITCH, R.N. 1966 The effect of the discontinuation of injection on the transpired turbulent boundary layer. Sc. D. thesis, Dept. Chem. Eng., MIT. *Blowing of air into air in new larger tunnel at MIT; one flow with no blowing, one run with blowing on front portion only; profiles of mean velocity; turbulent stresses; data tabulated in thesis. Flow probably not acceptably uniform or two-dimensional. Mean velocity*, figures 8, 15, 24, 30. Friction, figure 13. Reynolds stresses, figures 18–20, 34, 39, 40. Data are tabulated.*

LOYD, R.J. 1970 The turbulent boundary layer on a porous plate: An experimental study of the fluid dynamics with strong favorable pressure gradients and blowing. Ph. D. thesis, Dept. Mech. Eng., Stanford Univ.; also Rep. No. HMT-13, 1970 (with R.J. Moffat and W.M. Kays). *Eight flows, two with blowing, in strong negative pressure gradient; profiles of mean velocity, turbulence intensity. Mean velocity*, Reynolds stresses*. Data are tabulated.*

McCULLOUGH, G.B. and GAMBUCCI, B.J. 1952 Boundary-layer measurements on several porous materials with suction applied. NACA RM A52D01b. *Filter paper, wire cloth, electromesh, sintered bronze. Profiles of* *mean velocity, not analyzed or digested. Mean velocity*, figures 5–6.*

McLEAN, J.D. and MELLOR, G.L. 1972 The transpired turbulent boundary layer in an adverse pressure gradient. Int'l. J. Heat Mass Transf. **15**, 2353–2369. *Mean velocity*, figure 4. Wall friction*, figures 6–8.*

McQUAID, J. 1966 Incompressible turbulent boundary layers with distributed injection. Ph. D. diss., Univ. Cambridge. See also "Experiments on incompressible turbulent boundary layers with distributed injection", Gt. Brit., ARC R&M 3549, 1968, and "The calculation of turbulent boundary layers with injection", Gt. Brit., ARC R&M 3542, 1968. *Uniform injection at rates up to 0.008, mostly at constant pressure, but some work with pressure gradient; one flow with step in blowing; Preston tube; profiles of mean velocity; data are tabulated in thesis and in R&M 3549. Intermittency*, figures 1, 19. Mean velocity*, figures 4–7, 21, 25–27.*

McQUAID, J. 1968 Experiments on incompressible turbulent boundary layers with distributed injection. Gt. Britain, Aeron. Research Council, R&M 3549. *Mean velocity*, figures 17, 36, 39–43, 75–76, 90–92, etc. Friction, figure 20. Data are tabulated.*

MICKLEY, H.S. and DAVIS, R.S. 1957 Momentum transfer for flow over a flat plate with blowing. NACA TN 4017. *Mean velocity*, figures 2, 5–7. Wall friction*, figures 4, 8, 9.*

MICKLEY, H.S., ROSS, R.C., SQUYERS, A.L., and STEWART, W.E. 1954 Heat, mass, and momentum transfer for flow over a flat plate with blowing or suction. NACA TN 3208. *Wrong data; repudiated by authors (see insert in aero copy). Growth rate*, figure 11. Friction*, figure 19.*

MOFFAT, R.J. 1967 The turbulent boundary on a porous plate: Experimental heat transfer with uniform blowing and suction. Ph. D. thesis, Dept. Mech. Eng., Stanford Univ.; also Rep. No. HMT-1, 1967 (with W.M. Kays); see also Int. J. Heat Mass Transf. **11**, No. 10, 1968 (with W.M. Kays). *Several flow series with uniform suction or blowing and uniform heat transfer at constant pressure; profiles of mean temperature (mean velocity interpolated from data of Simpson); Stanton numbers; all data tabulated. Mass transfer*, figures 19, 22. Mean velocity*, figures 31–34. Data are tabulated.*

MUGALEV, V.P. 1959 Eksperimental'nie issledovanie dozvukovogo turbulentnogo pogranichnogo sloia na plastine so vduvom. Izv. VUZ, Aviatsionnaia Tekhnika, No. 3, 72–79. Translated as The experimental investigation of the subsonic turbulent boundary layer on a plate with injection, RAND Corp. T-142, 1960. *Blowing rates up to 3%. Mean velocity*, figures 2, 3.*

MUZZY, R.J. 1966 Mixing within a turbulent boundary with surface mass addition. Eng. thesis, Dept. Aeron. and Astron., Stanford Univ. *Mean* *velocity*, figures 4, 5, 6–10.*

NIHOUL, J.C.J. 1977 Turbulent boundary layer bearing silt in suspension. Phys. Fluids **20**, No. 10, Part 2, S197-S202. *Mean velocity*, figure 3.*

ORLANDO, A.F., MOFFAT, R.J., and KAYS, W.M. 1974 Turbulent transport of heat and momentum in a boundary layer subject to deceleration, suction and variable wall temperature. Dept. Mech. Eng., Stanford Univ., Rep. No. HMT-17. *Boundary layer on sintered surface. Various combinations of positive pressure gradient and suction. Also heat transfer. Profiles of mean velocity, mean temperature, fluctuations, correlations. Mean velocity*, figures 5.1, 5.3, 5.5, 5.7. Mean temperature, figures 5.2, 5.4, 5.6, 5.8. Reynolds stresses*, figures 6.1–6.5, 6.10, 6.11. Data are tabulated.*

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PAPELL, S.S. 1960 Effect on gaseous film cooling of coolant injection through angled slots and normal holes. NASA Technical Note D-299. *Slot or severl rows of holes. Effectiveness*, figure 2. Geometry*, figure 1. Data are tabulated.*

POWELL, R.W. and GRIFFITHS, E. 1935 The evaporation of water from plane and cylindrical surfaces. Trans. Inst'n. Chem. Eng. **13**, 175–192 (discussion 192–198). *Mass transfer*, figures 4–8.*

RAMNEFORS, M.O. and NYDEN, O.B. 1984 The effect of suction or injection on coherent structures in a turbulent boundary layer. In *Preprints, Ninth Symposium on Turbulence*, Dept. Chem. Eng., Univ. Missouri (Rolla), Paper 4. (X.B. Reed, Jr., ed.). *Mean velocity*, figure 1. Reynolds stresses*, figures 2–4.*

REYNOLDS, G.A. and SARIC, W.S. 1982 Experiments on the stability of the flat-plate boundary layer with suction. AIAA Paper 82-1026. *Eigenfunctions*, figures 4–6.*

RICE, W. 1958 Momentum and heat fluxes in a turbulent air flow over a wet, smooth boundary. Ph. D. thesis, Dept. Mech. Eng., Texas A&M College. *Mean velocity*, temperature, figure 10.*

ROBERTS, S.C. and RANDALL, C.A. Jr. 1967 An experimental investigation of the effect of fluid injection on the skin-friction coefficient of a porous flat plate. Aerophys. Aerosp. Eng. Dept., Mississippi State Univ., Aerophys. Res. Rep. No. 79. *Friction*, figures 5, 6. Mean velocity*, figure 7. Reynolds stresses*, figure 13.*

ROTTA, J.C. 1970 Control of turbulent boundary layers by uniform injection and suction of fluids. 7th Congress, Int’l. Council of Aeron. Sciences, ICAS Paper No. 70-10.

ROTTA, J.C. 1970 Control of turbulent boundary layers by uniform injection and suction of fluid. Jahrbuch 1970 der DGLR, 91–104. *Growth rate*, figure 2. Mean velocity*, figures 8, 9. Friction*, figures 10, 11.*

SARNECKI, A.J. 1959 The turbulent boundary layer on a permeable surface. Ph. D. thesis, Cambridge Univ. *Configuration similar to Dutton’s; various surface materials; profiles of mean velocity with uniform suction; discussion of intermittency but no useful measurements. Mean velocity*, figures 7, 9, 13, 17–24.*

SCESA, S. 1954 Effect of local normal injection on flat-plate heat transfer. Ph. D. thesis, Dept. Mech. Eng., Univ. California (Berkeley). *Velocity*, figures 5, 6, 7, 8, 9. Friction*, figure 10. Temperature*, figure 18. Data are tabulated.*

SCHETZ, J.A. and KONG, F. 1981 Turbulent boundary layer over solid and porous surfaces with small roughness. AIAA Paper 81-0418. *Velocity*, figures 7, 15, 20. Reynolds stresses.*

SCHETZ, J.A. and NERNEY, B. 1977 Turbulent boundary layer with injection and surface roughness. AIAA J. **15**, 1288–1294. *Balance*, figures 1, 3. Mean velocity*, figures 9, 10. Reynolds stresses*, figure 11.*

SENDA, M., SUZUKI, K., and SATO, T. 1979 Turbulence structure related to the heat transfer in a turbulent boundary layer with injection. In *Preprints, Second Symposium on Turbulent Shear Flows*, Imperial College, 9.17–9.22. *Geometry*, figure 1. Reynolds stresses*, figures 5, 6, 8, 9.*

SENDA, M., HORIGUCHI, S., SUZUKI, K., and SATO, T. 1981 A structural study on a turbulent boundary layer with transpiration. In *Preprints, Third Symposium on Turbulent Shear Flows*, UC Davis, 10.7–10.12.

SENDA, M., TOMONARI, N., and SUZUKI, K. 1985 Intermittent structure of a transpired turbulent boundary layer. In *Preprints, Fifth Symposium on Turbulent Shear Flows*, Cornell Univ., 9.1–9.6. *Intermittency*, figure 3. Reynolds stresses.*

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SIMPSON, R.L. 1970 Characteristics of turbulent boundary layers at low Reynolds numbers with and without transpiration. J. Fluid Mech. **42**, 769–802. *Velocity*, figures 1, 5–7, 10, 11. Reynolds stresses*, figures 13, 14.*

SIMPSON, R.L., KAYS, W.M., and MOFFAT, R.J. 1967 The turbulent boundary layer on a porous plate: an experimental study of the fluid dynamics with injection and suction. Dept. Mech. Eng., Stanford Univ., Rep. HMT-2. *Mean velocity*, figures 10, 11, 24–26, 28, others. Data are tabulated.*

SIMPSON, R.L., MOFFAT, R.J., and KAYS, W.M. 1969 The turbulent boundary layer on a porous plate: experimental skin friction with variable injection and suction. Int'l. J. Heat Mass Transf. **12**, 771–789. *Friction*, figure 5.*

SIMPSON, R.L., WHITTEN, D.G., and MOFFAT, R.J. 1970 An experimental study of the turbulent Prandtl number of air with injection and suction. Int. J. Heat Mass Transf. **13**, 125–143. *Rehash of data from three theses. Mean velocity*, figure 3. Mean temperature*, figures 2, 4.*

SMITH, K.A. 1962 The transpired turbulent boundary layer. Sc. D. thesis, Dept. Chem. Eng., MIT. *Uniform blowing, air into air; profiles of mean velocity and turbulence intensity for two flows with blowing; mean velocity in sublayer measured with hot wire; turbulence intensity but not mean velocity for two flows without blowing; all data tabulated in thesis. Shearing stress computed from mean velocity field, leading to friction velocity based on* τ_{max} *(see AIAA Notes). Mean velocity*, figures 9–12. Friction*, figures 15, 16. Reynolds stresses*, figures 20, 21, 29–32, 34–37, 39–45. Data are tabulated.*

SMITH, T.H. 1969 Hot-film characteristics in a turbulent boundary layer with foreign-gas injection. Ph. D. thesis, Dept. Mech. Eng., Univ. Utah. *Mean velocity*, figures VII.1–2, 13–16. Reynolds stresses*, figures VII.17–20, XI.4–5.*

STEVENSON, T.N. 1964 The use of Preston tubes to measure the skin friction in turbulent boundary layers with suction or injection. Coll. Aeron., Cranfield, Rep. Aero No. 173. *Cylindrical model with porous section following solid ogival nose; for mean-velocity profiles see Coll. Aeron. Rep. Aero 177. Friction*, figure 4.*

STEVENSON, T.N. 1964 Experiments on injection into an incompressible turbulent boundary layer. College Aeron., Cranfield, Rep. Aero No. 177. *Boundary layer on body of revolution with blowing. Data not completely reported. Mean velocity*, figures 11–13.*

TENNEKES, H. 1964 Similarity laws for turbulent boundary layers with suction or injection. Thesis, Delft (see also J. Fluid Mech. **21**, 689–703, 1965). *Turbulent boundary layer at constant pressure with mild uniform suction (including asymptotic suction layer); profiles of mean velocity. Growth rate*, figure 3. Mean velocity*, figures 7–20, 26.*

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Chapter 5: The Shear Layer

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Turbulent cylindrical mixing layer

Major surveys and theory

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Chapter 6 on Round wake (not completed in actual book)

Classical round wake

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Major surveys and theory

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Chapter 7 on Plane wake (not completed in actual book)

Classical plane wake

Major surveys and theory

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Chapter 8: Round jet into fluid at rest

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Round jet with swirl

Major surveys and theory

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PRATTE, B.D. and KEFFER, J.F. 1972 The swirling turbulent jet. Trans. ASME (J. Basic Eng.) **94D**, 739–748 (see also Ph. D. thesis by PRATTE, ”*Swirling turbulent jets*,” Dept. Mech. Eng., Univ. Toronto, 1968). by B.D. Pratte. *Jet with moderate swirl. Profiles of mean axial and tangential velocities, Reynolds stresses; growth rate, evolution on axis; a few spectra. Argument about* l/x *and* l/x^2 *decay for axial and swirl velocities. Geometry*, figure 1. Growth rate*, figure 2. Mean velocity*, figures 3, 4. Reynolds stresses*, figures 5, 6. Velocity decay*, figure 8, Static pressure*,*

figures 10, 11.

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Round jet with different gases

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Jets with odd shapes

Major surveys and theory

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RAJARATNAM, N. and SUBRAMANYA, K. 1967 Three-dimensional free jets. J. Royal Aeron. Soc. **71**, 858–859. *Other people's data. Scatter in decay law reduced by using nozzle area/perimeter as length scale. Decay*, figures 1, 2.*

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MARSTERS, G.F. 1979 The effects of upstream nozzle shaping on incompressible turbulent flows from rectangular nozzles. Trans. Canadian Soc. Mech. Eng. **5**, 197–203. *Contours of total pressure; profiles of mean velocity, Reynolds stress. Least uniform flow is for sharp-edged nozzle. Geometry*, figure 1. 3-D view*, figure 2. Mean velocity*, figure 3. Isovels*, figure 4. Turbulence contours*, figures 7–10.*

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Multiple round jets

Major surveys and theory

Experimental data

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1950 Sloop and Morrell, NACA E9I21

Transition of round jet

Major surveys and theory

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Chapter 9 Plane jet

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Impinging plane jet

Major surveys or theory

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Wall jet on curved surface

Major surveys or theory

Experimental data

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Film cooling

Major surveys or theory

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Plane jet reattachment; Coanda effect

Major surveys or theory

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3-D wall jets

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Wall jet along cylinder

Major surveys or theory

Experimental data

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Impingement of round jet

Major surveys or theory

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KOOPMAN, R.N. 1975 Local and average transfer coefficients for multiple impinging jets. Ph. D. thesis, Univ. Minnesota. *Student of Sparrow. Row of circular jets; naphthalene sublimation. Local and average mass-transfer coefficients. Mass transfer*, figures 6.1–6.8.*

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Stability of laminar wall jet

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Radial Coanda effect

Major surveys or theory

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Chapter 11: The Plane Plume

Classical plane plume

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Classical round plume

Major surveys and theory

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Free convection boundary layer

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Experimental data

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Chapter 12: Flow Control

Drag of screens and applications

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DANNENBERG, R.E., WEIBERG, J.A., and GAMBUCCI, B.J. 1954 The resistance to air flow of porous materials suitable for boundary-layer-control applications using area suction. NACA TN 3094. *Fig. 3-8, pressure difference vs. suction velocity; table 1, characteristics of porous materials. Data not tabulated.*

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velocity; fig. 7, 8, resistance coefficient vs. porosity; fig. 11, longitudinal turbulence vs. resistance coefficient.

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Major surveys or theory

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