NOTES

CHAPTER I

1. Herman Weyl, Space, Time and Matter, (New York: Dover, 1952), p.102.

2. Theodor Kaluza, "Zur Unitätsproblem der Physik," Sitzungsberichte der Preussischen Akademie der Wissenschaften, LIV (1921), pp.966-972.

3. Quoted in Varadaraje Raman, "Kaluza, Theodor Franz Eduard," Dictionary of Scientific Biography, (1974), VII, p.212; "The idea of attaining the electrical field by using a five-dimensional cylinder world is completely new and never occurred to me. For the moment, I consider the idea quite extraordinary."

4. Ibid., p.211.

5. Albert Einstein, The Meaning of Relativity, 6th edition, (Princeton: Princeton University Press, 1956), pp.93-94.

6. Albert Einstein, "Kaluza's Theorie des Zusammeinhanger von Gravitation und Electrizität," Sitzungberichte der Preussischen Akademie der Wissenschaften, VI (1927), pp.23-25 and pp.26-30.

7. Oskar Klein, "Quantentheorie und fünfdimensionale Relativitätstheorie," Zeitschrift fur Physiks, XXXVII, 12 (1926), pp.895-906.

8. Louis De Broglie, "L'Univers A Cinq Dimensions et la Mécanique Ondulatoire," Le Journal de Physique et Le Radium, Serie 6, Tome VIII, (Fevrier, 1927), pp.65-73.

9. Oskar Klein, "Sur L'Article de M.L. DeBroglie <<L'Univers A Cinq Dimensions et la Mécanique Ondulatoire>>, Le Journal de Physique et Le Radium, Serie 6, Tome VIII, (Avril, 1927), pp.242-243.

10. Louis DeBroglie, "Réponse a La Note de M.O. Klein," Le Journal de Physique et Le Radium, Serie 6, Tome VIII, (Avril, 1927), p.244.

11. Theodor Kaluza, "Zur Relativitätstheorie," Physikalische Zeitschrift XXV (1924), pp.604-606; "Über ban Energeinhalt der Atomkerne," Physikalische Zeitschrift, XXIII (1922), pp.474-476.

12. Wolfgang Pauli, The Theory of Relativity, (New York: Pergamon Press, 1958), p.230.

13. H.C. Corben, "A Generalization of Special Relativity Theory," Nature, CLVIII, No.3990 (April, 1946), p.516.

14. Gunnar Nordström, "Über die Möglichkeit das elektromagnetische Feld und das Gravitationsfeld zu vereinigen," Physickalische Zeitschrift, XV (May 15, 1914), pp.504-506.

15. Jagdish Mehra, Einstein, Hilbert and the Theory of Gravitation, (Boston: D. Reidel, 1974), p.6.

16. Albert Einstein and A.D. Fokker, "Die Nordströmsche Gravitationstheoire von Standpunkt Absoluten Differentialkalkuls," Annalen der Physics, XLIV (1914), pp.321-328.

17. Edward Kasner, "Einstein's Cosmological Equations," Science, LIV, No.1396 (September 30, 1921), pp.304-305; "The Einstein Solar Field and Space of Six Dimension," Science, LIII, No.1367 (March 29, 1920), pp.238-239; "Note on Einstein's Theory of Gravitation and Light," Science, LII, No.1348 (October 29, 1920), pp.413-414; "Einstein's Theory of Gravitation: Determination of the Field by Light Signals," American Journal of Mathematics, XLVIII (January 1921), pp.20-28; "The Impossibility of Einstein's Fields Immersed in A Flat Space of Five Dimensions," American Journal of Mathematics, XLVIII (April 1921), pp.126- 129; "Finite Representations of the Solar Gravitational Field in Flat Space of Six Dimensions," American Journal of Mathematics, XLVIII (April 1921), pp.130- 134; "Geometrical Theorems on Einstein's Cosmological Equation," American Journal of Mathematics, XLVIII (June, 1921), pp.217-221.

18. Kasner, "Einstein's Theory of Gravitation: Determination of the Field by Light Signals," op.cit., p.28.

19. Bernhard Riemann, "On The Hypotheses Which Lie at the Basis of Geometry," Nature, VIII (May 1,1873), p.17.

20. Ibid.

21. Max Jammer, Concepts of Space, (Cambridge, Massachusetts: Harvard University Press, (1969), p.174.

22. William Kingdon Clifford, Mathematical Papers, ed. Robert Tucker, (New York: Chelsea Publishing Company, 1965), pp.21-22; originally in Cambridge Philosophical Society's Proceedings II, 1876, pp.157-158.

"I hold in fact:

(1) That small portions of space are in fact of a nature analogous to little hills on a surface that is on the average flat; namely that the ordinary laws of geometry are valid in them.

(2)That this property of being curved or distorted is continually being passed on from one portion of space to another after the manner of a wave.

(3) That this variation of the curvature of space is what really happens in that phenomena which we call the motion of matter, whether ponderable or ethereal.

(4) That in the physical world nothing else takes place but this variation, subject (possibly) to the law of continuity."

23. William Kingdon Clifford, The Common Sense of the Exact Sciences, (New York: Knopf, 1946), p.225; see also Chapter IV, "On the Bending of Space," pp.193-204.

24. Ernst Mach, The Science of Mechanics, trans. Thomas J. McCormack, (LaSalle, Illinois: Open Court, 1960), p.590.

25. Ibid., pp.590-591.

26. Jammer, op.cit., p.179.

27. Marie Antoinette Tonnelat, Les Théories Unitaire de L'Électromagnétisme et de La Gravitation, (Paris: Gauthier-Villiers, 1965), p.161.

28. André Lichnerowitz, Théories Relativiste de La Gravitation et de L'Éectromagnétisme, (Paris: Masson, 1954), pp.180-214.

29. Peter G. Bergmann, An Introduction to the Theory of Relativity, (New York: Dover, 1976).

30. Pauli, op.cit., pp.224-232.

31. D.K. Sen, Fields and/or Particles, (New York: Academic Press, 1968).

32. John C. Graves, The Conceptual Foundations of Contemporary Relativity Theory, (Cambridge, Massachusetts: MIT Press, 1971).

33. Oskar Klein, "Quantentheorie und fünfdimensionale Relativitätstheorie," Zeitschrift fur Physik, 37, 12 (1926), pp.895-906; "The Atomicity of Electricity as a Quantum Theory Law," Nature, CXVIII, No.2971 (October 9,1926), p.516; "Zur fünfdimensionale Darstellung der Relativitätstheories," Zeitschrift fur Physik, 46, 3-4 (1927), pp.188-208.

34. Oskar Klein, cited in Jagdish Mehra, op.cit., p.53.

35. Oskar Klein, "On the Theory of Charged Fields," New Theories in Physics, (Paris: International Institute of Intellectual Cooperation, 1939), pp.77-93; "Meson Fields and Nuclear Interaction," Arkiv for Matematik, Astronomi och Fysik, Band 34A, No:1 (1946), pp.1-19; "Generalizations of Einstein's Theory of Gravitation Considered from

the Point of View of Quantum Field theory," Helvetica Physics Acta, Supplement IV (1956), pp.58-71.

36. Oskar Klein, quoted in Mehra, op.cit., p.80.

37. "Mesotonic" is the term used by Klein when referring to the forces described by Yukawa. Today, these are better known as the strong nuclear force and are modeled by the Yukawa Potential.

38. Klein, "On the Theory of Charged Fields," p.79.

39. Klein, "Meson Fields and Nuclear Interactions," p.3.

40 Klein, "Generalizations of Einstein's Theory," p.59.

41. Ibid.

42. Albert Einstein and W. Mayer, "Einheitliche Theorie von Gravitation und Electrizität (I)," Sitzungberichte der Preussischen Akademie der Wissenschaften, XXV (1931), pp.541-577; "Einheitliche Theorie von Gravitation und Electrizität (II)," Sitzungberichte der Preussischen Akademie der Wissenschaften, XI-XII (1932), pp.130-137.

43. G.C.M. [McVittie], Abstract No. 2309, Science Abstracts: Section A, Physics, (1932), XXXV, p.585.

44. Oswald Veblen and Banesh Hoffman, "Projective Relativity," Physical Review, XXXVI (September 1, 1930), pp.810-822.

45. D. Van Dantzig, "Theorie der projektiven Zusammenhangs n-dimensionaler Räume," Math.Ann., CVI (1932), p.400; D. Van Dantzig, "Zur allgemein projecktiven Differentialgeometrie," Amsterdam Proceedings XXXV (1932), pp.524 and 535, and XXXVII (1934), p.150; B. Hoffman, The Quarterly Journal of Mathematics, VII (1936), p.20; B. Hoffman, "The Vector Meson Field and Projective Relativity," Physical Review, LXXII (1947), p.458; B. Hoffman, "The Gravitational, Electromagnetic and Meson Fields and the Similarity Geometry," Physical Review, LXXIII (1948), p.30; W. Pauli, "Über die Formuliering der Naturgesetze mit fünf homogen Koordinäten, I. Klassische Theorie," Annalen der Physik, XVIII (1933), p.305; J.A. Schouten "Zur Generelien Feldtheorie," Zeitschrift fur Physik, LXXXI (1933), pp.129 and 405; J.A. Schouten, "La Théorie projective de la Relativité," Ann. Inst. H. Poincaré V, No.1 (1935), p.51; J.A. Schouten and D. Van Dantzig, "On projective Connections and Their Application to the General field Theory," Annals of Mathematics, XXXIV (1933), p.271; J.A. Schouten and D. Van Dantzig, Annals of Mathematics, XXXIV (1939), p.37; J.A. Schouten and D. Van Dantzig, "Generalle Feldtheorie," Zeitschrift fur Physik, LXXVIII (1932), p.639; O. Veblen, Projektive Relativitätstheorie, (Berlin: J. Springer, 1933).

46. Pauli, op.cit., pp.229-230.

47. Albert Einstein and Peter G. Bergmann, "On a Generalization of Kaluza's Theory of Electricity," Annals of Mathematics, XXXIX, No.3 (July, 1938), pp.683-701.

48. Ibid., p.691.

49. Ibid., p.694.

50. Albert Einstein, Peter G. Bergmann and Valentine Bargmann, "On the Five-Dimensional Representation of Gravitation and Electricity," Theodor von Karman Anniversary Volume, (Pasadena: California Institute of Technology, 1941), pp.212-225.

51. Ibid., pp.24-25.

52. Yves Thiry, "Les Équations de La Théorie Unitaire de Kaluza," Comptes Rendus, Academie des Science, CCXXVI (1948), pp.216-218; Yves Thiry, "Sur La Régularité des Champs Gravitationnel et Électromagnétique dans Les Théories Unitaire," Comptes Rendus, Academie de Science, CCXXVI (June 7, 1948), pp.1881-1882; Yves Thiry, Étude Mathématique des Équations d'une Théorie Unitaire à Quinze Variables de Champs, (Thesis, Paris: Gauthier-Villiers, 1951); Pasqual Jordan, "Erweitung der projektiven Relativitätstheories," Annalen der Physik, VI, No.1 (1947), pp.219-228; Pasqual Jordan, "Fünfdimensionale Kosmologie," Astron.Nachr., CCLXXVI, No's.5 and 6(1948), p.193.

53. Eli Cartan, "Sur Les Variétés à Connexion Affine et La Théorie de La Relativité Générale," Ann. Ec. Norm. Sup., XL (1923).

54. Tonnelat, op.cit., p.183.

55. Graves, op.cit., p.257; At a much earlier date than had Dirac, J. Callinon had hypothesized a varying constant of curvature in "Les Espaces Géometrique," Revue Philosophique XXVII (1889), pp.588-595; see also Dirac, Proceedings of the Royal Society, CLXV (1938), p.199.

56. J. Podolanski, "Unified Field Theory in Six Dimensions," Proceedings of the Royal Society, CCI (March 22, 1950), pp.234-260.

57. Ibid., p.235.

58. Ibid.

59. Ibid.

60. I have been able to find thirty-seven different articles that Flint has either authored or collaborated on with others. These cover a period from 1928 to 1958.

61. H.T. Flint and J.W. Fisher, Contribution to Modern Ideas on the Quantum Theory," Proceedings of the Royal Society CXV (1927), pp.208-214.

62. H.T. Flint, "A Study of the Nature of the Field Theories of Electron and Positron and of the Meson," Proceedings of the Royal Society, CLXXXV (January 1946), pp.14-24.

63. H.T. Flint, "Quantum Equations and nuclear Field Theories," Philosophical Magazine, Series 7, XXXVI, No.260(September, 1945), pp.635-643.

64. Ibid., p.635.

65. H.T. Flint, "A Relativistic Basis of the Quantum Theory," Proceedings of the Royal Society, CXLIV (March 29, 1934), p.416.

66. Ibid.

67. H.T. Flint and J.W. Fisher, "The Equations of the Quantum Theory," Proceedings of the Royal Society, CXXVI (March 3, 1930), p.644; and Ibid., p.414.

68. W. Wilson, "The Quantum Theory and Electromagnetic Phenomena," Proceedings of the Royal Society, CII (1922), pp.478-483.

69. W. Wilson, "Relativity and Wave Mechanics," Proceedings of the Royal Society, CXVIII (April, 1928), pp.441-448.

70. Ibid., p.441.

71. Ibid., p.448.

72. W. Wilson and J. Cattermole, "The Elementary Particle," Philosophical Magazine, XXVII (January, 1939), pp.84-93.

73. W. Wilson and H.T. Flint, "The Fundamental Unit of Electric Charge," Physical Society, Proceedings, L (May 2, 1938), pp.340-344.

74. W. Wilson, Theoretical Physics: Relativity and Quantum Dynamics, Volume III, (London: Methuen and Company, 1940), p.68.

75. J.W. Fisher, "The Wave Equation in Five-Dimensions," Proceedings of the Royal Society, CXXIII (April 6, 1929), pp.489-493; Fisher also co-authored several articles with Wilson and Flint.

76. Flint and Fisher, op.cit., p.208.

77. D. Meksyn, "A Unified Field Theory, Part I: Electromagnetic Field," Philosophical Magazine, XVII (January, 1934), pp.99-112; "A Unified Field Theory. Part II:

Gravitation," Philosophical Magazine, XVII (February, 1934), pp.476-482; "Neutrons," Nature, CXXXI, p.366.

78. Meksyn, "A Unified Field Theory, Part I," p.112.

79. Ibid.

80. G. Vranceanu, "La Théorie Unitaire des Champs et Les Hypersurfaces Non-Holonomous," Comptes Rendus, Academie de Science, CC (1935), pp.2056-2058; "Les Espaces Non-Holonomes et Leurs Applications Mécaniques," Mém. Science et Mathematic, LXXVI (1936); "Non-Holonomic Unified Field Theory," Journal de Physique et de La Radium, VII (December, 1936), pp.514-526.

81. Kentano Yano, "Unitary Non-Holonomous Field Theory. Parts I and II," Physics and Mathematics Society of Japan, Proceedings, XIX (October, 1937), pp.867-896 and XIX (November, 1937), pp.945-976; "Théorie de la Relativité," Comptes Rendus, CCIV (February 1, 1937), pp.332-334.

82. J.G. Bennett, R.L. Brown and M.W. Thring, "The Unified FIeld Theory in a Curvature Free Five-Dimensional Manifold," Proceedings of the Royal Society, CXCVIII (July 22, 1949), pp.39-61.

83. Ibid., p.59.

84. Ibid., p.39.

85. Ibid., p.40.

86. Ibid., p.42.

87. H.C. Corben, "A Generalization of the Special Relativity Theory," Nature, CLVII, No.3990 (April 20, 1946), p.157; "A Classical Theory of Electromagnetism and Gravitation," Nature, CLVI, No.3961 (September 29, 1945), pp.388-389; "A Classical Theory of Electromagnetism and Gravitation. I. Special Relativity," Physical Review, LXIX, No's. 5 and 6 (March 1 and March 16, 1946), pp.225-234; "Special Relativistic Field Theories in Five-Dimensions," Physical Review, CXX, No's. 12 and 13 (December 1 and December 15, 1946), pp.947-953.

88. The Maxwell Lorentz equations are stated as follows:

$\delta F_{\nu\sigma}/\delta x_\mu + \delta F_{\sigma\mu}/\delta x_\nu + \delta F_{\mu\nu}/\delta x_\sigma = 0$, and $\delta F_{\mu\nu}/\delta x_\nu = 4\pi i_\mu$.

$k_\mu = (1/c)F_{\mu\nu}i_\nu$, where the $\mu,\nu = 0,1,2,3,4$ in Corben's theory.

The Lorentz condition is stated as,

$\delta A_\nu/\delta x_\nu = 0$ by application of which $\delta F_{\mu\nu} = \delta A_\nu/\delta x_\mu - \delta A_\mu/\delta x_\nu$.

89. Corben, "Special Relativistic Field Theories," p.948.

90. Corben, "A Classical Theory of Electromagnetism and Gravitation. I, " p.226.

91. Ibid.

92. Corben, "Special Relativistic Field Theories," P.948.

93. Ibid.

94. H.C. Corben, "A Unified Field theory With Varying Charge and Rest Mass," Nuovo Cimento, IX (March, 1952), pp.235-252.

95. K.C. Wang and K.C. Cheng, "A Five-Dimensional Field theory," Physical Review, LXX, No's. 7 and 8 (October 1 and October 15, 1946), pp.516-518.

96. W. Pauli and S. Kusaka, Physical Review, LXIII (1943), p.400; Here they show that experiment and the weak coupling are in agreement.

97. Peter G. Bergmann, "Unified Field Theory with Fifteen Variables," Annals of Mathematics, XLIX (January 1948), pp.255-264.

98. Ibid., p.225; A similar statement is found in Jagdish Mehra, ed., A Physicist's Conception of Nature, (Dordrecht-Holland: D. Reidel, 1973), pp.69-70. "Theories with a fifteenth variable are a possible generalization of Kaluza's five-dimensional approach. Einstein and I considered, what is today rightly known as the Jordan-Thiry theories, in the late thirties. We did not publish this attempt, as it did not achieve Einstein's objective, to yield a classical model of elementary particles."

99. W. Wilson, Theoretical Mechanics, p.441; "Dr. H.T. Flint has drawn my attention to a recent paper by O. Klein ('Z.f.Physik', vol. 46, p.188 (1928)) in which an extension to five dimensions, exactly similar to that given in this paper is described. The corresponding part of this paper was written some time ago and without any knowledge of Klein's work, and it is fairly obvious a corollary to ideas contained in the paper by the writer to which reference is made ('Roy.Soc.Proc.,' A, vol. 102, p.478 (1922))."

100. Klein, "Meson Fields and Nuclear Interaction," p.19; "Before finishing the last proof I noticed a paper by H.T. Flint (Proc.Roy.Soc. 185, 14, 1946) where the problem of nuclear interaction has been attacked on lines which are somewhat related to , although essentially different from those developed here. At a later occasion I hope to discuss more closely the relations of these two investigations."

CHAPTER II

1. The most general Riemannian metric has far more than ten terms, but the restrictions and symmetries of the General Theory of Relativity reduce the number of terms to only ten for the case of gravitation. This sentence refers only to the metric as here defined.

2. Peter G. Bergmann, An Introduction to the Theory of Relativity, p.254; Einstein and Bergmann, op.cit., p.683.

3. When dealing with five-dimensional theories, it has become accepted practice to consider variations over the Greek indices as indicating values of 0 to 4 (or 1 to 5), with 0 (or 5) representing the fifth dimension. Variations over Roman numerals represent only the values of 1 to 4 corresponding to the normal four dimensions of space-time.

4. Banesh Hoffman, Einstein: Creator and Rebel, (New York: Viking Press, 1974), p.403.

5. Bergmann, op.cit., p.259; Einstein and Bergmann, op.cit., p.684; When a comma or semi-colon are used with the superscripts or subscripts, a partial differentiation is being indicated with respect to the numeral after the marking, i.e. $\delta\gamma_{\mu\nu}/\delta x_o = 0$ is the same as $\gamma_{\mu\nu,o} = 0$.

6. Bergmann, op.cit., pp.258-259; Einstein and Bergmann, op.cit., p.686.

7. Einstein and Bergmann, Ibid., p.684.

8. Ibid., p.687; A bar over a variable indicates that the variable is now being evaluated in a transformed system, i.e. $\bar{}$.

9. Bergmann, op.cit., p.267.

10. Sen, op.cit., p.87; Mehra, op.cit., p.53.

CHAPTER III

1. M.A. Tonnelat, The Principles of Electrodynamic Theory and of Relativity, trans. A.J. Knodel (Dordrecht-Holland: D. Reidel, 1966), pp.403-404.

2. Einstein, The Meaning of Relativity, op.cit., p.164.

3. Graves, op.cit., p.258.

4. Since there are no guidelines to our concept of the fifth dimension, we have a situation where anything is possible concerning speculation on its physical characteristics. However, the vast variety of possible speculations in this sense is too wide. We must find some specific physically related phenomena to prove the existence of a fifth dimension or the usefulness of it as a concept. At present we can only restrict our speculations along the lines that the fifth dimension must be so constructed as to be non-experiential.

5. Pauli, op.cit., p.230.

6. Graves, op.cit., p.258.

7. Ibid.

8. M.A. Tonnelat, Einstein's Unified Field Theory, trans. Richard Akerib, (New York: Gordon and Breach, 1966), p.7.

9. Ibid., p.8.

10. Tonnelat, Principles of Electromagnetic Theory, op. cit., p.404.

11. Tonnelat, Einstein's Unified Field Theory, op. cit., p.7.

12. Tonnelat, Principles of Electromagnetic Theory, op. cit., p.403.

13. Graves, op.cit., p.257.

14. Since the theory only duplicates the Einstein-Maxwell equations without providing additional equations for speculation, the theory is said to be non-predictive. It cannot predict events beyond those that can be predicted from the Einstein-Maxwell equations. If it were to add something new, and was thus predictive in nature, it would be possible to test the hypothesis independently and accept its validity.

15. Graves, op.cit., pp.257-258.

16. Ibid.

17. Ibid., p.258.

18. Pauli, op.cit., p.230.

19. Ibid.

20. These are found in Flint's, Corben's, Klein's and other theories.

21. Corben, "A Classical Theory of Electromagnetism," p.225.

22. H.T. Flint, "The Uncertainty Principle in Modern Physics," Nature, CXXIX, No.3264 (May 21, 1932), pp.746-747.

23. Graves, op.cit., p.258.

24. Einstein, loc.cit.

25. Peter G. Bergmann, "Topics in the General Theory of Relativity," notes taken by Nicholas J. Wheeler, Summer Institute of Theoretical Physics, (Waltham, Massachusetts: Brandeis University, 1957), p.42.

26. Einstein, loc.cit.; The emphasis on the word 'apparently' is Einstein's.

27. Bergmann, loc.cit.

28. A.R. Forsythe, Geometry of Four Dimensions, (Cambridge, England: At the University Press, 1930), p.xi.

29. Graves, op.cit., pp.182-185.

30. Erwin Schrödinger quoted in Graves, Ibid., p.184.

31. John A. Wheeler, "Curved Empty Space as the Building Material of the Physical World: An Assessment," Logic, Methodology and the Philosophy of Science, Proceedings of the 1960 International Congress, eds. Ernest Nagel, Patrick Suppes and Alfred Tarski, (Stanford: Stanford University Press, 1962), p.361.

32. Graves, op.cit., p.191.

33. Lawrence Sklar, Space, Time and Spacetime, (Berkeley: University of California Press, 1974), p.64.

34. Wesley C. Salmon, "The Curvature of Physical Space," Foundations of Space-Time, Minnesota Studies in the Philosophy of Science: Vol. III, eds. John Earman, Clark Glymour and John Stackel, (Minneapolis: University of Minnesota Press, 1975), pp.281-283.

35. Hans Reichenbach, The Philosophy of Space and Time (New York: Dover, 1956), pp.35-37; also in Arthur Schlipp, ed., Einstein: Philosopher and Scientist, (LaSalle, Illinois: Open Court, 1949), pp.295-299.

36. Wesley, op.cit., pp.286-296.

37. Ibid.

38. H.P. Robertson, "Geometry as a Branch of Physics," Problems of Space and Time, ed. J.J.C. Smart, (New York: MacMillan, 1964), p.240; also in Schlipp, op.cit.

39. Henri Poincaré quoted in Robertson, Ibid., p.239.

40. Mach, op.cit., p.591; "We have not yet found an accoucheur who has accomplished parturition through the fourth dimension."

41. Forsythe, op.cit., p.viii.

42. Albert Einstein, "Geometry and Experience," Ideas and Opinions, trans. Sonja Bergmann, (New York: Dell, 1976), pp.230-231; This was originally a lecture before the Prussian Academy of Sciences on January 27, 1921.

43. Albert Einstein, "Reply to Criticisms," in Schlipp, op.cit., p.678.

44. Bennett, Brown and Thring, loc.cit.

45. Podolanski, loc.cit.

46. Ibid., p.234.

47. Flint, "The Equations of the Quantum Theory," loc.cit.

48. Flint, "A Relativistic Basis of the Quantum Theory," loc.cit.

49. Wilson, Theoretical Physics, op.cit., p.120.

50. Andrezj Trautman, "Theory of Gravitation," in Mehra, op.cit., pp.179-180.

51. Albert Einstein, "On the Method of Theoretical Physics," Ideas and Opinions, op.cit., pp.267-268.

52. Peter G. Bergmann, "Physics and Geometry," Logic, Methodology and the Philosophy of Science, Proceedings of the 1964 International Congress, (Amsterdam: North Holland Publishing, 1965), p.347.

53. Bergmann, "Topics," op.cit., p.49.

54. Robertson, op.cit., p.240.

55. Milic Capek, The Philosophical Impact of Contemporary Physics, (Princeton: Von Nostrand, 1961), p.181.

56. G.J. Whitrow, "Why Space has Three Dimensions," The British Journal for the Philosophy of Science VI, No.21 (May, 1955), pp.23-24.

57. Ibid., p.20.

58. Graves, op.cit., p.199.

59. Ira Freeman, "Why is Space Three-Dimensional?," American Journal of Physics XXXVII, no.12 (December, 1969), p.1224; This article was based on W. Buchel,

"Warum hat der Raum drei Dimensionen?," Physikalische Blatter, XIX, 12 (December, 1963), pp.547-549.

60. B. Abramenko, "On Dimensionality and Continuity of Physical Space and Time," The British Journal for the Philosophy of Science, IX, No.34 (August, 1958), p.109.

61. Immanuel Kant quoted in Whitrow, op.cit., p.19.

62. Christopher Gregory, "Extra-Dimensionality in Relativity and Space," Abstracts on the Fifth International Conference on Gravitation and the Theory of Relativity, (Tbilisi: Publishing House of Tbilisi, 1968), p.246.

63. Freeman, op.cit., p.1222.

64. Whitrow, op.cit., pp.30-31.

65. Gregory, op.cit., p.245.

66. Graves, loc.cit.

67. Ibid., p.192.

68. Ibid.

69. I.J.Good, "Winding Space," The Scientist Speculates,, ed. I.J. Good, (New York: Capricorn Books, 1965), pp.330-336.

70. René Dugas, A History of Mechanics, trans. J.R. Maddox, (Neuchatel, Switzerland: 1955), p.533.

71. Richard C. Tolman, Relativity, Thermodynamics and Cosmology, (Oxford: At the Clarendon Press, 1934), pp.366-367; Dugas, Ibid., p.532.

72. Kasner, "Einstein's Solar Field and Space of Six Dimensions," op.cit., p.238.

73. Nathaniel Rosen and Itzhak Goldman, "A Universe Embedded in a Five-Dimensional Flat Space," General Relativity and Gravitation, II (1971), p.383.

74. Bennett, Brown and Thring, op.cit., p.61.

75. Hartland S. Snyder, "Quantized Space-Time," Physical Review, LXXI, No.1 (January 1,1947), pp.38-41.

76. Ibid., p.39.

77. Podolanski, op.cit., pp.234-235.

78. Robert Herman. Yang-Mills Kaluza-Klein and the Einstein Program, (Brookline, Massachusetts: Math Sci Press, 1978).

79. Ibid., p.iv.

80. Bergmann, "Topics," loc.cit.

81. H.T. Flint and E.M. Williamson, "The Theory of Relativity, the Electromagnetic Theory and the Quantum Theory," Il Nuovo Cimento, VIII, No.5 (June 1, 1958), pp.680-681.

82. H.T. Flint, "The Uncertainty Principle in Modern Physics," Nature, CXXXIX, No.3264 (May 21, 1932), p.746.

83. Pauli, The Theory of Relativity, op.cit., p.225.

84. Ibid., p.232.

85. See also Graves, op.cit., p.258.

86. Trautman, op.cit., p.180.

87. Graves, op.cit., p.197.

88. Capek, op.cit., p.281.

89. Tonnelat, Principles of the Theory of Electromagnetism, op.cit., pp.403-404.

90. Graves, op.cit., p.219.

91. Capek, op.cit., p.176.

CHAPTER IV

1. Wang and Cheng, op.cit., pp.516-518.

2. Wilson, "Relativity and Wave Mechanics," op.cit., pp.441-448.

3. Bergmann, "Topics," loc.cit.

CONCLUSION

1. Albert Einstein, "Physics and Reality," Ideas and Opinions, op.cit., p.304; Originally from The Journal of the Franklin Institute, CCI, No.3 (March, 1936).

2. Mach, loc.cit.

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Last Updated 22 December 1999

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