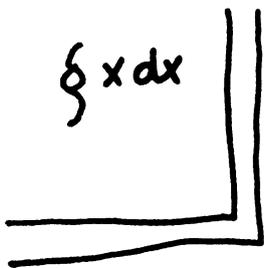




SIAMO TUTTI DIRETTORI
CAN-CAN CHIMICO

17

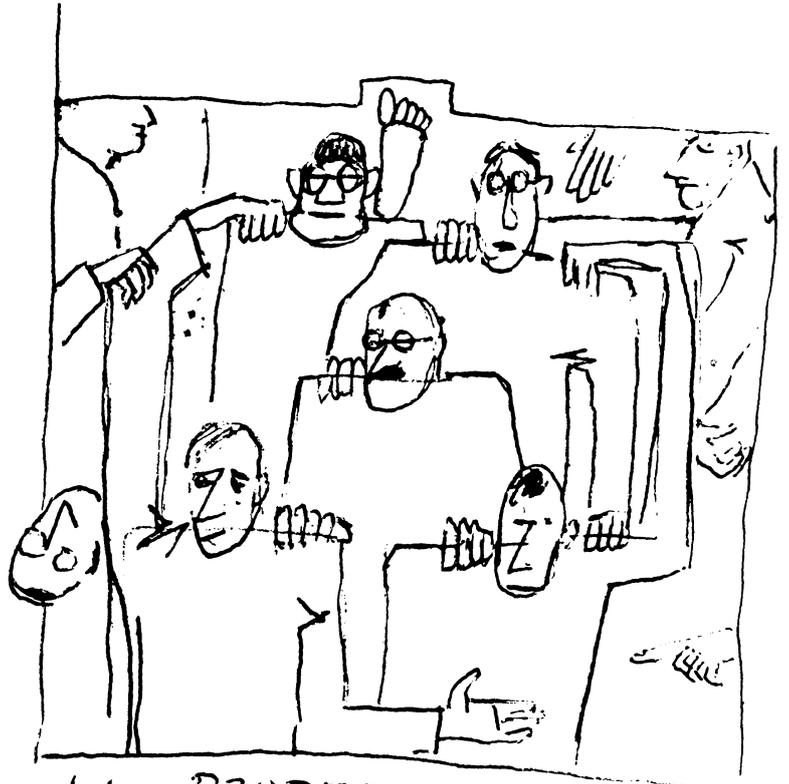
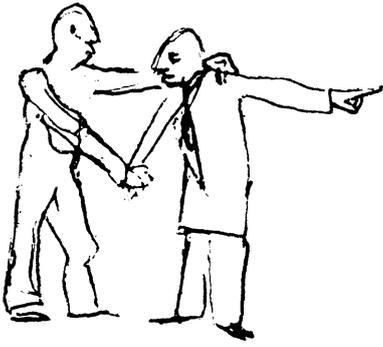


E ANCHE LA MATEMATICA

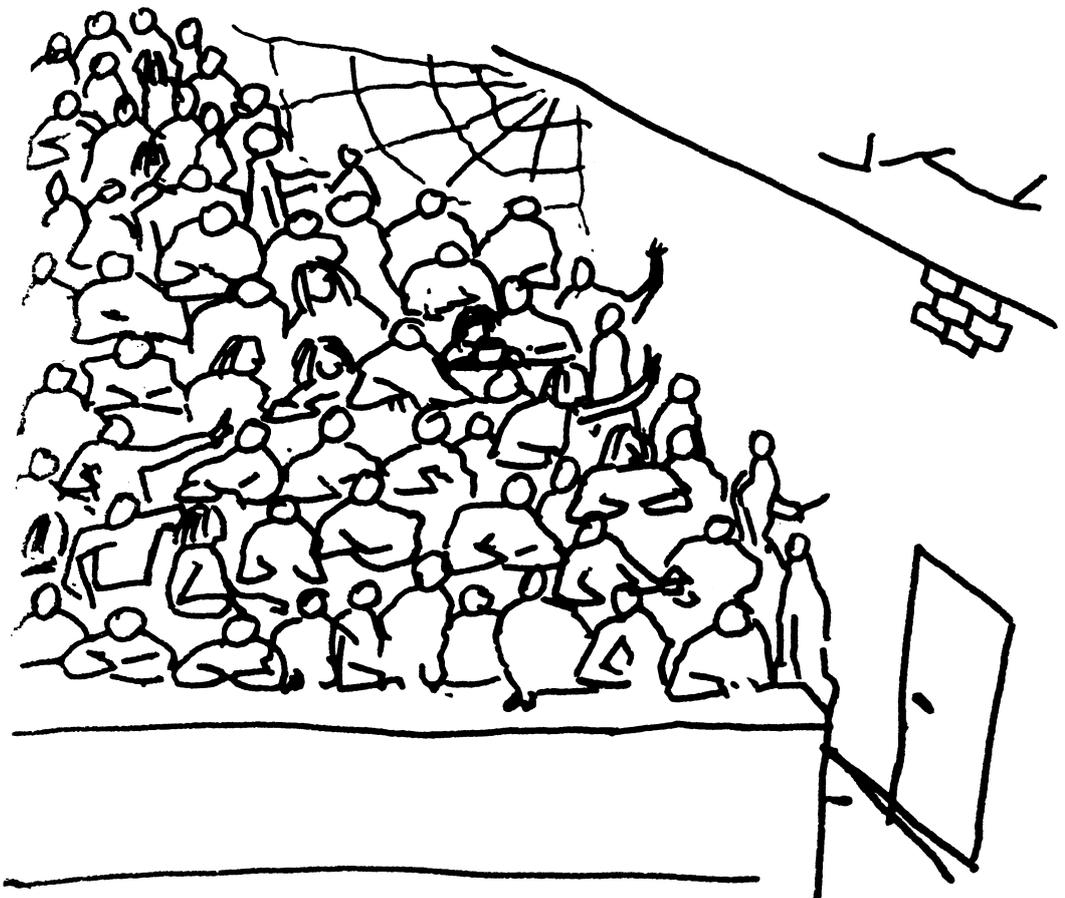


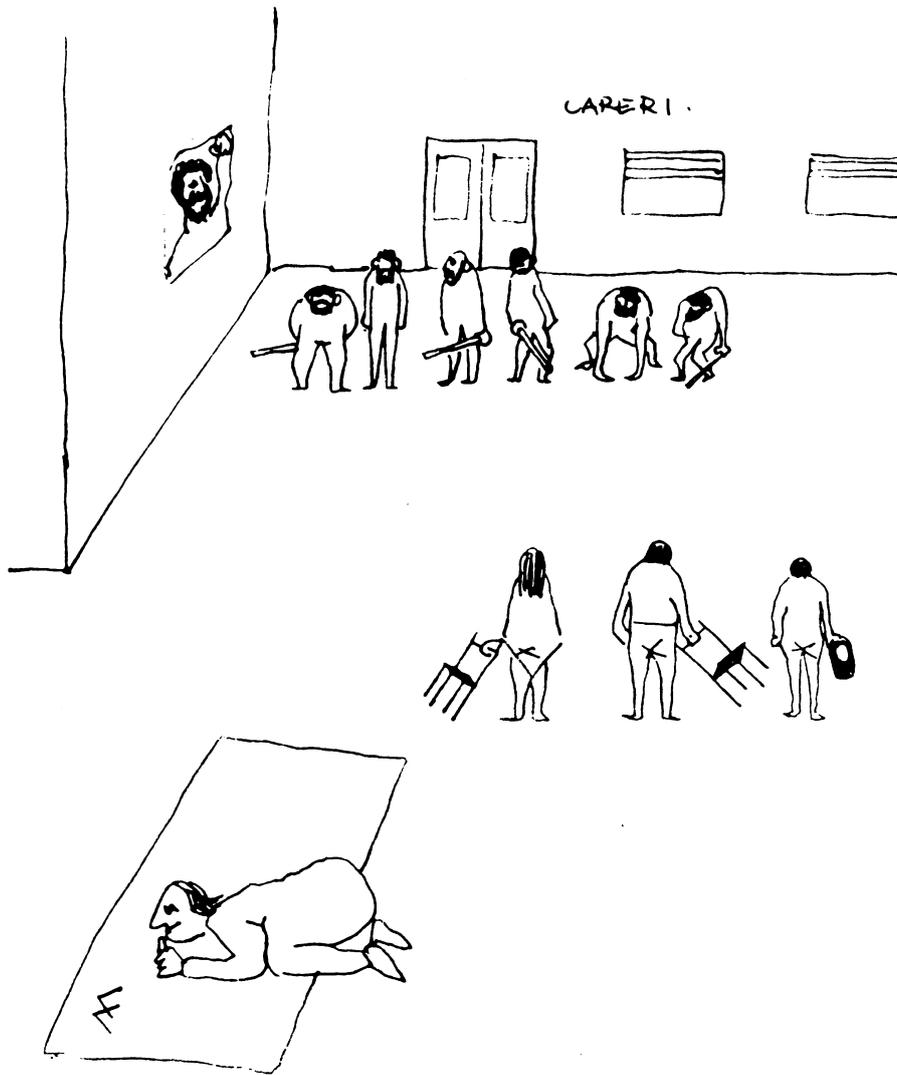
IN RICERCA DEL MODUS VIVENDI

18



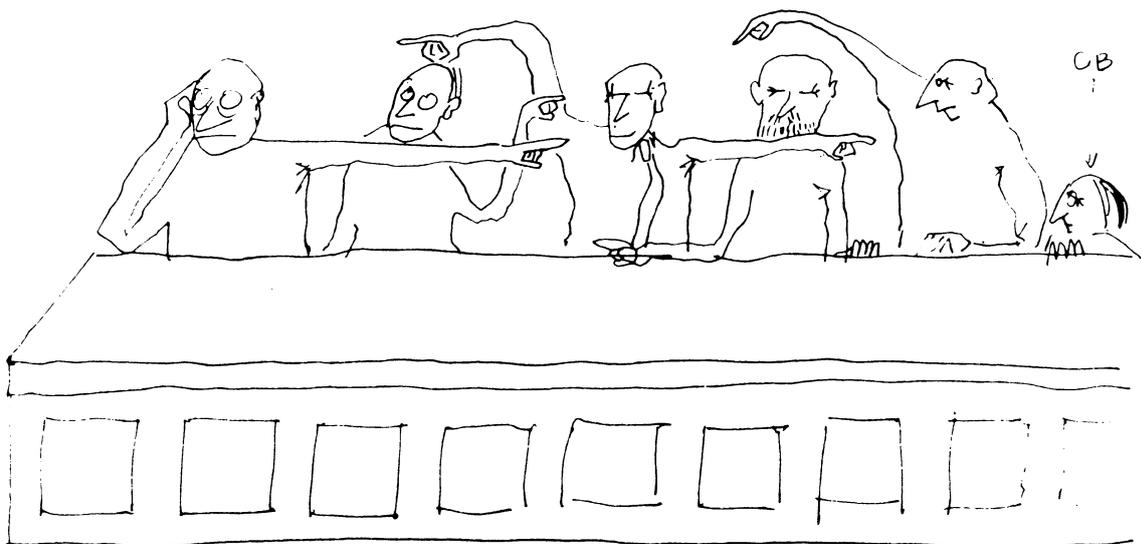
LA PROPEDEUTICITÀ



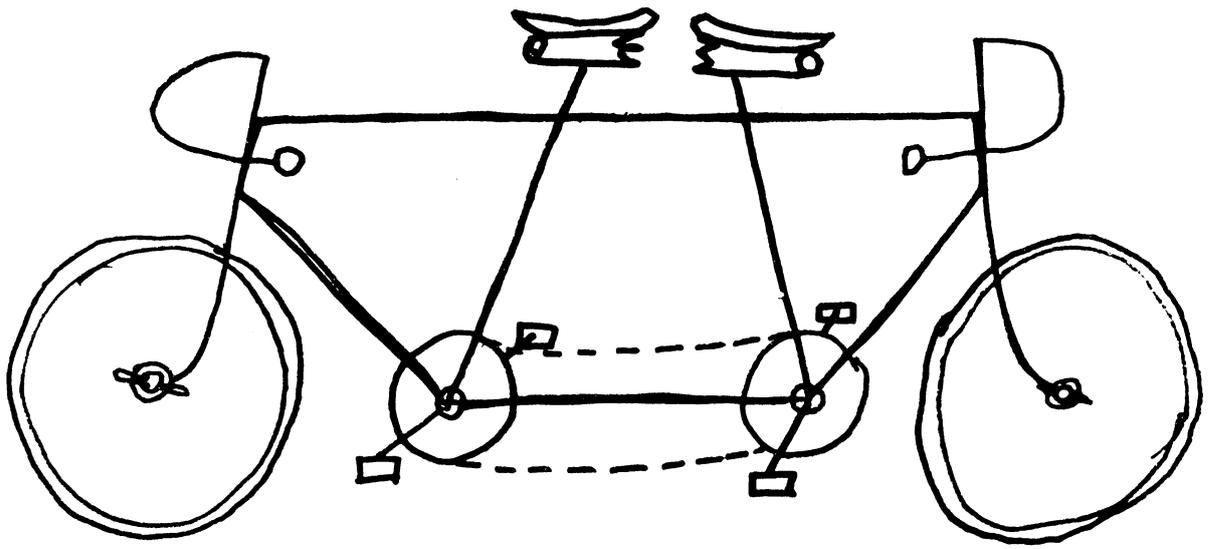


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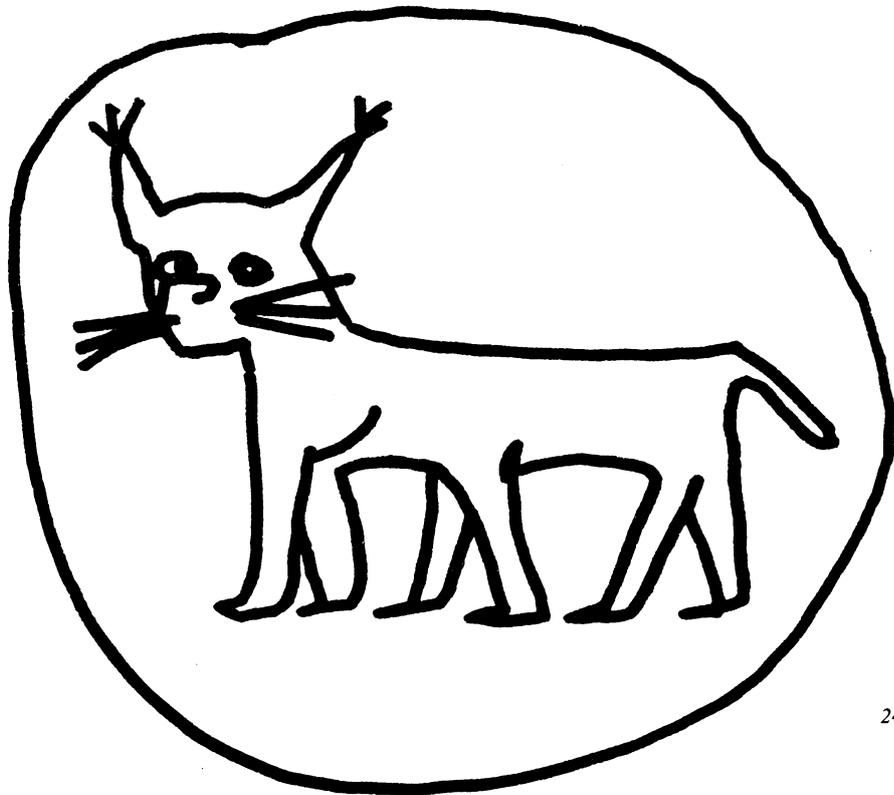
Direzione dell' Istituto di Fisica Maria Montessori.
la Selta del Direttore.



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PROBARE ET REPROBARE ! 23



24

REFERENCES AND NOTES

- 1) Student in the sense of “goliard” (wandering student).
- 2) In reality he was referring to the Nordkette, as Valentino Braitenberg pointed out to me.
- 3) Ferdinand Cap (b. 1924), Professor of Theoretical Physics at the University of Innsbruck, has worked in elementary particle physics and on general relativity. He had met Touschek for the first time during the fifties on the occasion of a few international conferences. Joseph Rothleitner, Professor of Theoretical Physics at the University of Innsbruck, met Touschek for the first time at the University of Heidelberg about 15 years ago. At my request he has sent me a letter (dated 8 October 1980) about the last weeks of the life of Bruno in Innsbruck.
- 4) Ernst Gartner (b. Vienna), designer and painter, teaches arts and drawing at the Gymnasium in Reutte, Tyrol. He had been a schoolmate of Bruno from the primary schools in Vienna and remained his closest friend during all his life.
- 5) Valentino Braitenberg (b. Bolzano, 1926) studied medicine and specialized in neurology and psychiatry at the University of Rome. After a few years devoted to research on the brain in Germany and the USA, he entered, under the influence of Bruno Touschek and Eduardo Caianello, into a research group of the Institute of Theoretical Physics of the University of Naples, which later became the Naples Section of the National Group for Cybernetics of the Consiglio Nazionale delle Ricerche (CNR). From 1961 to 1968 Braitenberg was Associate Professor of Cybernetics at the University of Naples. Called to a chair of Biology and Applied Science at CalTech, he however accepted the almost contemporary offer of the codirection of the Max Planck Institut für Biologische Kybernetik, in Tübingen. On my request Braitenberg sent me a long letter, dated 27 July 1980, parts of which have been used here.
- 6) Laboratori Nazionali di Frascati: *Bollettino di Informazione* n. 4, 30 aprile 1978. The announcement of B. Touschek’s death was dated 31 May and given on the first page of the *Bollettino* n. 4, dated 30 April but which appeared a few days after 1 June.
- 7) C. Bernardini: *Paese Sera*, 4 June 1978: “In Italy, Touschek became a designer”, with the subheading “Loss of a major scientific personality”.
- 8) A. Bietti, *l’Unità*, 13 June 1978: “From the Great Era in Physics”, with the subheading: “Death of Bruno Touschek”.
- 9) Ugo Amaldi, *Corriere della Sera*, 22 July 1978: “Who was the man of No. 137”, with the subheading “Commemoration in Frascati of the physicist Bruno Touschek”.
- 10) When drafting this paragraph I used the notes which I wrote on 28 February 1978, when I went to visit Bruno Touschek at the La Tour Hospital. I asked him if he was prepared to give me a chronological account of certain occasional remarks made in the past, and on receiving an affirmative reply, I took a few notes with his permission. On returning to Rome I arranged my notes, had them typed and sent them off to Igl’s asking him to fill in the gaps, and correct any errors. Bruno did not receive my manuscript until 29 April, and replied on 2 May with a long series of small corrections to my text, which is reproduced here in full. The only additions are a few historical references and more detail concerning the work performed at Hamburg, which I received in the letters from Wideröe (Ref. 22), and on the work at Göttingen, which I obtained from Paul (Ref. 32).
- 11) W.L. Shirer, *The Rise and Fall of the Third Reich* (Secker and Warburg, London, 1960).
- 12) Hellmut Andics, *50 Jahre unseres Lebens, Österreichs Schicksal seit 1918* (Verlag Fritz Molden, Vienna, 1968).
Erich Zollner, *Geschichte Österreichs* (Verlag für Geschichte und Politik, Vienna, 1970), 4. Auflage. French translation: *Histoire de l’Autriche, des origines à nos jours* (Horvath, Vienna–Munich, 1965).
See also: Silvio Furlani and Adam Wandruszka: *Austria e Italia, Storia a due voci* (Jugend und Volk, Vienna–Munich, 1973; Cappelli Editore, Bologna, 1974).
- 13) Paul Urban (b. Purkersdorf, near Vienna, 1905) obtained an engineering diploma (electrotechnics and machine construction) in 1928 at the Technische Hochschule in Vienna, and a Ph.D. (in physics and mathematics) at the University of Vienna in 1935. He has worked in industries (1928–30), in the Technical Section of the Austrian State Railroads (1931–39), and as Assistant (to Professor Hans Thirring) at the Institut für Theoretische Physik of the Universities of Vienna (1940–45) and Innsbruck (1945–46). Finally he became Professor of Theoretical Physics at the University of Graz (1947–1975), of which, since 1975, he has been “Professor Emeritus”. He is the author of more than one hundred papers dealing with quantum mechanics, atomic and nuclear physics and elementary particle theory. He is also the author of a book of considerable interest: *Topics in applied quantum electrodynamics* (Springer Verlag, Vienna–New York, 1970), and edited, in collaboration with his pupil, Walter Thirring: “The Schrödinger equation”, Lectures presented at the International Symposium 50 years Schrödinger Equation, *Acta Phys. Austr. Suppl.* 17 (1977).

- 14) Arnold Sommerfeld (1868–1951) studied mathematics at the University of Königsberg and in 1893 went to Göttingen where he made his “habilitation” under the supervision of Felix Klein, whom Sommerfeld considered always his “master”. In 1900 Sommerfeld was appointed Ordinary Professor of Mathematics at the Technische Hochschule of Aachen, where for six years he collaborated with a few high-level engineers in the solution of a number of technical problems (resonance phenomena in bridges, construction of locomotives, construction of ships, etc.). In 1906 he was called to the chair of theoretical physics of the University of Munich that he kept until his retirement. Sommerfeld was one of the first supporters of the theory of special relativity of Einstein, which constituted one of the many subjects he used to deal with in his many courses of lectures. Starting from 1920 he made many important contributions to quantum theory, on the use of which he published, in 1919, a famous treatise *Atombau und Spektrallinien* (Vieweg, Braunschweig, 1919), of which a few editions appeared in the successive years. During the twenties Sommerfeld made various important contributions to the quantum theory developed by Heisenberg, Born, Schrödinger, Bohr, Dirac, and others, and to which he devoted a further volume: *Atombau und Spektrallinien: Wellenmechanischer Ergänzungsband* (Vieweg, Braunschweig, 1929). Sommerfeld is well known not only for his many important papers and this fundamental book, but also for his six volumes of lectures in theoretical physics (Leipzig, 1942–62). Among his many pupils it is enough to recall: E. Fuess, H. Hoül, W. Kassel, W. Lenz, W. Pauli, W. Heisenberg, H.A. Bethe. An extensive biography, in which also his vicissitudes during the nazi regime are recalled, has been published by Ulrich Benz: *Arnold Sommerfeld*, Vol. 38 of the collection “Grosse Naturforscher” published under the direction of Dr. Heinz Degen (Wissenschaftliche Verlagsgesellschaft m.b.H., Stuttgart, 1975).
- 15) Edmund Hlawka (b. 1916), Professor of Mathematics at the University of Vienna has made fundamental contributions, especially to the theory of numbers.
- 16) Paul Harteck (b. 1902), Professor of Chemical Physics, and subsequently Rector (1948–50) of the University of Hamburg and (since 1951) Distinguished Research Professor of Physical Chemistry at the Rensselaer Polytechnic Institute, Troy, N.Y. He is the author of more than 150 papers on experiments on para- and ortho-hydrogen, deuteron plus deuteron nuclear reactions, separation of hydrogen isotopes, artificial radioactivity, diffusion of slow neutrons, isotope separation by diffusion, and the chemistry of the Earth’s atmosphere.
- 17) P.P. Koch (1879–1945). His most well known scientific contribution goes back to the years before 1912, when he developed high sensitivity and great accuracy method [Ann. Phys. (Germany) 30, 841 (1909); 34, 377 (1911); 39 705 (1912); 40, 797 (1913); 41, 115 (1913)] for the photometer analysis of the X-ray photographic plates obtained by B. Walter and R. Pohl [Ann. Phys. (Germany) 29, 331 (1909); 38, 507 (1912)] with a wedge-shaped slit, the width of which, of a few μm in the upper part becomes of a few μm at its lower end. A beam of X-rays impinging on this slit produces a diffraction figure, whose maximum becomes wider moving from the upper to the lower part of the slit. By this method Koch gave evidence for the wave nature of X-rays before the famous work by W. Friedrich, P. Knipping and M. von Laue [Ber. Bayer. Akad. Wiss., 303 (1912); Ann. Phys. (Germany) 41, 971 (1913)]. Koch’s method and results are described in some detail in Chapter 3 on “Die Röntgenspektrum” of the 1919 edition of the book by Arnold Sommerfeld, *Atombau und Spektrallinien*.
- 18) W. Lenz [Frankfurt (Main), 1888–1952] studied in Göttingen (1906–1908) and Munich (1908–1912) and later worked on various developments of quantum mechanics with G. Wentzel, W. Pauli, P. Jordan, A. Unsöld and J.H.D. Jensen. See P. Jordan, “The life of W. Lenz”, *Phys. Bl.* 13, 269 (1957).
- 19) H.J.D. Jensen (1907–1973), Professor of Theoretical Physics at the Universities of Hamburg and Heidelberg, author of numerous works on nuclear physics; shared with Maria Goeppert-Mayer the 1963 Nobel Prize for Physics, for their discoveries concerning nuclear shell structure. No biography of Jensen has been published, according to his wishes, *Phys. Bl.* 29, 233 (1973).
- 20) H. Suess (b. 1909), subsequently Professor of Theoretical Physics at the University of California (La Jolla), author of numerous papers on the abundance of the elements, and later on the radioactivity of the atmosphere and hydrosphere. Of particular importance is the paper, which he wrote in collaboration with O. Haxel and H.J.D. Jensen, on nuclear shell structure.
- 21) Eduard Suess (1831–1914), born in London of Viennese parents, was the most famous geologist of the second half of the nineteenth century. Starting from 1857 he was Professor of Geology at the University of Vienna, and, from 1888, President of the Austrian Academy of Sciences. His name is bound up with the work *Anlitz der Erde* (Vienna, 1883, 1909), *La face de la Terre* (Paris, 1905, 1909), a grand comparative synthesis of the knowledge at the end of the nineteenth century of the structure of the terrestrial globe.
- 22) At my request, R. Wideröe sent me on 10 November 1979, a long letter concerning his collaboration with Bruno Touschek. Other letters followed with further information and details.
- 23) Rolf Wideröe (b. Oslo, Norway, 1902), gained a Degree in Engineering at Karlsruhe, conceived the betatron in 1922, and submitted a thesis (Aachen, 1927) in which he set out the bases for the multiple acceleration of charged particles. He constructed the first European betatron (Hamburg 1943–44), and later a number of other machines

of this same type for therapeutic use, working in the laboratories of Brown Boveri (Baden 1946–49). Wideröe has made a few other inventions in the field of accelerators; in particular, in 1943, while working in Hamburg, he proposed for the first time the use of storage rings for high-energy particles, in order to study nuclear reactions produced in the collision of particles moving with the same energy but opposite velocity [German Patent No. 876279 (1943)].

- 24) The betatron, as a source of particles for the production of nuclear reactions, certainly was much inferior to the cyclotron and to the voltage multiplier, both already very much used during the thirties.
- 25) D.W. Kerst, *Phys. Rev.* **58**, 841 (1940); **59**, 110 (1941); **60**, 47 (1941).
- 26) D.W. Kerst and R. Serber, *Phys. Rev.* **60**, 53 (1941).
- 27) R. Kollath (1900–1978), Professor of Physics at the University of Mainz, author of papers on collisions between slow electrons and ions against the molecules of gases. “At that time Kollath belonged to the AEG Research Laboratory (founded and directed by C. Ramsauer). He also had problems because his wife was Jewish” (Ref. 22). He is the author of the book *Teilchenbeschleuniger* (Friedr. Vieweg and Sons, Braunschweig, 1955).
- 28) W. Heitler, *The quantum theory of radiation* (Clarendon Press, Oxford, 1936).
- 29) In his letter (Ref. 22), Wideröe relates the same episode, but with two unimportant variants: the first is that the SS official aimed at Bruno’s head because he had stopped to tie his shoe-lace; the second was that he was found by the doctor in the roadside gutter. I have adhered to the account which Bruno Touschek gave me.
- 30) Bruno, talking with me, used this expression in Italian, but Sir Rudolf Peierls has suggested that probably he referred to the operetta “Die Fledermaus” of Johann Strauss, where a very permissive prison is described.
- 31) K. Gund (1907–1953) born in Vienna, studied in his native town and, starting from 1931, worked, in Vienna, in the laboratories of Siemens und Halske. In 1936 he transferred to Siemens Reiniger Werke, Erlangen (Germany) where, in 1941, he started to develop a 6 MeV betatron for medical applications.
- 32) W. Paul (b. 1913), Professor of Experimental Physics at the University of Bonn, author of numerous papers on atomic physics. He introduced high-energy experimental physics with accelerators in Germany.
- 33) W. Paul, *Naturwissenschaften* **36**, 31 (1949).
- 34) Richard Becker (1887–1955), Professor of Theoretical Physics at the Technische Hochschule in Berlin, and at the University of Göttingen, author of numerous papers and excellent books on atomic physics, ferromagnetism, and plasticity.
- 35) O. Haxel (b. 1909), Professor of Physics at the University of Heidelberg, author of numerous papers on nuclear physics. Particularly important is the paper in collaboration with H.J. D. Jensen and H. Suess on the shell model of nuclei.
- 36) H.C. Kopfermann (1895–1963), Professor of Physics at the Universities of Göttingen and Heidelberg, author of numerous important papers on spectroscopy and nuclear physics, and of the book *Kernmomente* (Akademische Verlagsgesellschaft, Leipzig, 1940). See the biography by V. Weisskopf in *Nucl. Phys.* **52**, 177 (1964) where the list of his papers is also given.
- 37) Werner Heisenberg (1901–1974), Professor of Theoretical Physics at Leipzig, Berlin, Göttingen and Director of the Max Planck Institut für Physik und Astrophysik in Munich. One of the founders of quantum mechanics, and author of many fundamental papers and books on atomic and molecular physics, ferromagnetism, cosmic radiation, and elementary particles. For an extensive biography see: Armin Hermann, *Heisenberg*, Rowohlt Monographien (Rowohlt Taschenbuch Verlag GmbH, Reinbek bei Hamburg, 1976 and 1977).
- 38) F.G. Houtermans (1903–1966), Professor of Experimental Physics at Kharkov, Göttingen and Berne, author of numerous papers on spectroscopy, nuclear physics, and on the determination of the age of rocks based on the measurement of their content of uranium and potassium and their decay products. Of particular importance are certain papers dated 1929, written in collaboration with G. Gamow on the alpha decay of nuclei, and others, written in 1930–31, in collaboration with R. d’E. Atkinson on the production of energy by means of nuclear reactions inside stars.
- 39) Ludwig Prandtl (1875–1953) was the founder of the boundary layer theory and the originator of the German school of aerodynamics. Among his many students in Göttingen the most notable was Theodore von Karman. By their competitive efforts the problem of describing turbulent flow was clarified in the mid-1920’s.

- 40) C.F. von Weizsäcker (b. 1912), a pupil of W. Heisenberg, has made various important contributions to physics and astrophysics. He developed the liquid-drop model of the atomic nucleus which led him to the derivation of the so-called Weizsäcker mass formula. He was also one of the first people to recognize that the energy irradiated by stars is provided by certain nuclear reactions taking place at their centre. Weizsäcker has also devoted a considerable part of his activities to philosophy and politics.
- 41) The Kaiser-Wilhelm-Gesellschaft was founded in Berlin in January 1911 and dissolved in Berlin, in June 1960, because after the Second World War it was not possible to continue it without some important modification and under the same name. On 26 February 1948, there was founded in Göttingen the Max-Planck-Gesellschaft, which assumed that part of the patrimony of the previous Kaiser-Wilhelm-Gesellschaft which had been saved from the war. For more details see *50-Jahre Kaiser-Wilhelm-Gesellschaft und Max-Planck-Gesellschaft zur Förderung der Wissenschaften, 1911–1961*, Beiträge in Dokumenten, Göttingen, 1961.
- 42) Paul Urban has sent me three letters, dated 30 June, 4 July and 16 September 1980. The most important information is contained in the first one.
- 43) In the article “In Memory of Hans Thirring” written by Paul Urban, immediately after his death, one can read that the antimilitarism of Hans Thirring had begun already during the First World War, and his interest in the problems of peace had been strongly reinforced in the middle of the thirties when international tension increased owing to the advance of the Japanese troops in the Far East, and of the Italian Troops in Abyssinia.
- 44) J. Slepian, X-ray tube, USA Patent No. 1645305 asked for 1 March 1922 and granted 10 October 1928.
- 45) R. Wideröe, *Arch. Elektrotech.* 21, 387 (1928).
- 46) For a detailed account of the development of this idea, see for example: R. Wideröe, “Das Betatron”, *Z. angew. Phys.* 5, 187 (1953); “Die ersten zehn Jahre der Mehrfach-Beschleunigung, Einige historische Notizen” *Wiss. Z. der F. Schiller Univ., Jena* 13, 491 (1964).
- 47) K. Gund, *Naturwissenschaften* 34, 343 (1947); K. Gund and H. Reich, *Z. Phys.* 126, 383 (1949); K. Gund and W. Paul, *Nucleonics* 7, 36 (1950).
- 48) See also: W. Paul, “Early days in the development of accelerators”, *Aesthetics and Science*, Proc. Int. Symposium in honour of R.R. Wilson, 27 April 1979 (Fermi Nat. Accel. Lab., Batavia, 1979), p. 25.
- 49) Philip Ivor Dee (b. 1904), Professor of Natural Philosophy at the University of Glasgow, is well known in nuclear physics as an author of numerous papers, among which I should mention his collaboration with James Chadwick in the discovery of the neutron. He is the author of the third of the three papers which appeared together in *Proc. R. Soc., London, Ser. A*, 136 (1932):
 J. Chadwick, “The existence of the neutron”;
 N. Feather, “The collisions of neutrons with nitrogen nuclei”;
 P.I. Dee, “Attempt to detect the interaction of neutrons with electrons”.
 From 1939 to 1945, Dee was a superintendent of the Telecommunications Research Establishment, where he was in charge of the group responsible for the development of airborne centimetric radar devices.
- 50) R. Fraser: research physical chemist at Cambridge, where he worked for a few years after having been a lecturer at Aberdeen University.
- 51) John Currie Gunn (b. 1916), Professor of Natural Philosophy and Head of that department since 1973, at the University of Glasgow, is author of a long list of papers on theoretical physics.
- 52) Sir Rudolf Peierls (b. Berlin, 1907) studied theoretical physics in Berlin, Munich, Leipzig, and at the ETH of Zurich, under Sommerfeld, Heisenberg, and Pauli. He has been Professor of Applied Mathematics at the University of Birmingham (1937–63) and of Theoretical Physics at the University of Oxford (1963–74). In addition to many important papers on the theory of solids, nuclei, and fields, Peierls has published a few books: *Quantum theory of solids* (1955); *The laws of nature* (1955); *Surprises in theoretical physics* (1979). He is the editor of *A perspective of physics*, Vol. 1 (1977), Vol. 2 (1978).
- 53) Ian Naismith Sneddon (b. 1919), Simson Professor of Mathematics at the University of Glasgow, is author of almost one hundred papers on Fourier transforms and mixed boundary value problems in potential theory.
- 54) Walter Thirring (b. 1927), Professor of Theoretical Physics at the University of Vienna, author of many major papers on field theory and relativity.
- 55) Roy Chisholm (b. 1926) is now Professor of Applied Mathematics at the University of Kent. He has also worked at Glasgow, Cardiff, CERN, Texas, and Dublin. He has done research in quantum field theory, especially on

computational methods and on gauge theory, and in non-linear approximation theory, in particular on multivariate and other generalizations of Padé approximation.

- 56) E.W. Laing, *Philos. Mag.* **46**, 106 (1955).
- 57) B. Ferretti (b. Bologna, 1913), Assistant and later deputy of E. Fermi at the University of Rome. Subsequently Professor of Theoretical Physics at the University of Milan (1947), Rome (1948–1956) and Bologna (from 1956 onwards). Author of many important publications concerning quantum electrodynamics, field theory, and elementary particles.
- 58) E. Amaldi, “The years of reconstruction”, *Giornale di Fisica* **20**, 186 (1979); *Scientia* **114**, 29 (1979).
- 59) S. Weinberg, *Phys. Rev. Lett.* **19**, 1264 (1967); **27**, 1688 (1971).
A. Salam and J. Strathdee, IC/71/145, Int. Center Theor. Phys. Trieste (ICTP).
- 60) Sir (Charles) Maurice Yonge, C.B.E., F.R.S. (b. 1899), Professor of Zoology at the University of Glasgow, has devoted a great part of his activities to research on marine biology and has occupied administrative national and international positions. Among his publications I recall: *The seas* (1928); *A year on the great barrier reef* (1930); *British marine life* (1944); *The sea shore* (Collins, London–New York, 1949); *Oysters* (Collins, London–New York, 1960); *Physiology of mollusca* (ed. with K.M. Wilbur) (Academic Press, New York, 1964–1967).
- 61) M. Sands (b. 1919), at that time Professor of Physics at the California Institute of Technology. The friendship between Touschek and Sands went on for the successive years and gave rise to a renewed tight collaboration in 1968–69 on problems concerning the electron storage rings. In 1952–55 Sands participated in the design and construction of the first electron accelerator of energy greater than 1 GeV (1.5 GeV Synchrotron of CalTech), in 1959 he was the first to propose a design of a 300 GeV proton-synchrotron, together with W.K.H. Panofsky, in 1963–69 he was in charge of the SLAC project during the building and first operation of the 3 kilometre linear electron accelerator. He is the author of various books, among which I recall (in collaboration with W.C. Elmore): *Electronics: experimental techniques* (McGraw-Hill, New York, 1949); and (in collaboration with R.P. Feynman and R.B. Leighton): *The Feynman lectures in physics* (3 volumes) (Addison-Wesley, Reading, Mass., 1963–64). In recent years Sands became Faculty Dean at the University of California, Santa Cruz.
- 62) E.D. Courant, M.S. Livingston and H.S. Snyder, *Phys. Rev.* **88**, 1190 (1952).
- 63) E.D. Courant and H. Snyder, Brookhaven Internal Report 1953 (unpublished) and *Ann. Phys. (USA)* **3**, 1 (1958).
J.B. Adams, M.G. Hine and J.D. Lawson, *Nature* **173**, 926 (1953).
- 64) E. Persico, E. Ferrari and S.E. Segrè, *Principles of particle accelerators* (Benjamin, New York, 1968).
A.A. Kolomensky and A.N. Lebedev, *Theory of cyclic accelerators* (North Holland, Amsterdam, 1962).
- 65) Reported at the Third Annual Rochester Conference on High Energy Physics, Rochester, 1952 [see *Proceedings* (Univ. Rochester, NY, 1953), p. 50] and Royal Society Conference on Heavy Mesons, London, 1953.
- 66) E. Amaldi, G. Baroni, C. Castagnoli, G. Cortini and A. Manfredini, *Nuovo Cimento* **10**, 937 (1953).
E. Amaldi, G. Baroni, G. Cortini, C. Franzinetti and A. Manfredini, *Suppl. Nuovo Cimento* **12**, 181 (1954).
E. Amaldi, *Suppl. Nuovo Cimento* **4**, 179 (1956).
- 67) R.M. Brown, U. Camerini, P.H. Fowler, H. Muirhead, C.F. Powell and D.M. Ritson, *Nature* **163**, 47 (1948).
- 68) E. Fabri, *Nuovo Cimento* **11**, 479 (1954).
- 69) R. Dalitz, *Philos. Mag.* **44**, 1068 (1953). Dalitz presented his results at the Congrès international sur le Rayonnement cosmique, organized by the University of Toulouse, under the patronage of IUPAP, with the support of UNESCO, at Bagnères-de-Bigorre (6–11 July 1953).
- 70) Report of the International Congress on Heavy Unstable Elementary Particles and on High-Energy Events in Cosmic Rays, Padua, 12–15 April 1954, *Suppl. Nuovo Cimento* **12**, 163 (1954).
- 71) C. Dilworth, A. Manfredini, G.D. Rochester, J. Waddington and G.T. Zorn, “Report of the Committee on K-Particles”, submitted to the Conference of Ref. 70, *Suppl. Nuovo Cimento* **12**, 433 (1954).
- 72) G.F. Chew, *Phys. Rev.* **89**, 591 (1953);
G.F. Chew and F. Low, *Phys. Rev.* **101**, 1570 (1956);
G.F. Chew, “Theory of pion scattering and photoproduction” (University of Illinois, Urbana, Illinois, 1956), p. 1–140;

M. Cini and S. Fubini, "General properties of the fixed source meson theory", *CERN Symposium on High Energy Accelerators and Pion Physics* (CERN, Geneva, 1956), Vol. 2, p. 171–172.

- 73) G. Wentzel, *Helv. Phys. Acta* **25**, 569 (1952). See also J.M. Blatt, *Phys. Rev.* **72**, 466 (1947).
- 74) See, for example: S.S. Schweber, H.A. Bethe and F. de Hoffman, *Mesons and fields* (Row, Peterson and Co., Evanston, Ill., 1956).
- 75) M. Cini, *Nuovo Cimento* **10**, 526, 614 (1953).
- 76) M. Cini and S. Fubini, *Nuovo Cimento* **11**, 142 (1954).
- 77) F.J. Dyson, *Math. Rev.* **17**, 438 (1956).
- 78) This report is quoted in: D. Amati and B. Vitale, *Fortschr. Phys.* **7**, 375 (1959) and S. Fubini and J.D. Walecka, *Phys. Rev.* **116**, 194 (1959).
- 79) G. Feinberg, *Phys. Rev.* **108**, 898 (1975);
S.N. Gupta, *Can. J. Phys.* **35**, 1309 (1957);
V.G. Soloviev, *Nucl. Phys.* **6**, 618 (E7, 791): The problem is discussed on p. 65 of G. Morpurgo, "Strong interactions and reactions of hyperons and heavy mesons", *Ann. Rev. Nucl. Sci.* **11**, 41 (1961).
- 80) Abdus Salam, *Nuovo Cimento* **5**, 299 (1957).
- 81) M. Gell-Mann and Y. Ne'eman, "The weak current of the hadrons", Chapter 8 of *The eightfold way* (W.A. Benjamin Inc., New York, 1964), pp. 171–206.
- 82) T.D. Lee and C.N. Yang, *Phys. Rev.* **104**, 254 (1956).
- 83) C.S. Wu, E. Ambler, R.W. Hayward, D.D. Hoppes and R.P. Hudson, *Phys. Rev.* **105**, 1413 (1957).
- 84) The same choice was also made at the same time by other authors: R.P. Feynman and M. Gell-Mann, *Phys. Rev.* **109**, 193 (1958);
R.E. Marshak and E.C.G. Sudarshan, in *Proc. Int. Conf. on Mesons and Recently Discovered Particles* Padua-Venice, 1957 (Padua, 1957) and *Phys. Rev.* **109**, 1860 (1958).
- 85) R. Garwin, L. Lederman and M. Weinrich, *Phys. Rev.* **105**, 1415 (1957).
- 86) L.L. Foldy and S.A. Wouthuysen, *Phys. Rev.* **78**, 29 (1950).
- 87) W. Heisenberg, *Z. Naturforsch. a* **12**, 177 (1957).
- 88) The following comments are made on page 3 of the Bulletin of the Società Italiana di Fisica No. 12, of 4 March 1959:
The "Prize for Teaching Merit" amounting to 1,000,000 Lire, offered by the University of Palermo, by the Sicilian Regional Committee for Nuclear Research and by the University of Palermo's Institute of Physics, has been awarded to Professor BRUNO TOUSCHEK, of Austrian nationality, for the following reasons: "Bruno Touschek, born in Vienna, has lived in Italy since the end of 1952 being a Professor at the Scuola di Perfezionamento di Fisica Nucleare at the University of Rome. Over these years, he has published the results of his outstanding theoretical research, most of the work being performed in collaboration with colleagues and pupils. The research relates to the stability conditions of orbits in strong-focusing accelerators, the decay of the τ meson, the Tamm-Dancoff method, time reversal, the capture of negative heavy mesons with hyperon production, the conservation of leptonic number and the properties of symmetry in spinor fields. Some of the results contained in these papers have been recognized internationally: examples of these are the study of heavy meson capture and time reversal. This research activity is difficult to separate from his teaching activities which have always gone well beyond his official obligations. Up to 1954, the latter consisted of giving a course at the Scuola di Perfezionamento in Fisica Nucleare on 'Cosmic rays and elementary particles', and from 1954 onwards a course on Field theory. After 1956 these same courses were given by Touschek at the University of Pisa, in a series of short periodic visits. The often very lively and sometimes almost frenzied discussion of the subjects dealt with in his courses gave rise not only to a substantial part of the papers which carry his name, but also to various others from students who attended these courses. His personality and his human qualities have brought him close to his colleagues and collaborators, with whom he has shared his outstanding enthusiasm for the problems to which his attention is devoted at the particular moment. This happy combination of a researcher and master puts Touschek right in the forefront for the award of the Prize for Teaching Merit of the Società Italiana di Fisica".
- 89) *Proc. Int. School of Physics "Enrico Fermi", XLVI Course*, directed by B. Touschek (Academic Press, New York, and Periodici Scientifici, Milan, 1971).

- 90) The Casati Reform goes back to November 1859. Count Gabrio Casati (1798–1873) was Minister for Public Education in the Lamarmora Cabinet for only 6 months, during which he drew up the “Casati Law”, which remained in force with slight modifications up to the Gentile Reform of 1928. The need to suppress the certificate of Italian nationality for applications to participate in university competitions had been discussed in 1960 by G. Bernardini and myself with the Minister for Public Education, Giuseppe Medici, especially on 4 and 5 February, when the Minister came to Geneva to inaugurate the 29 GeV CERN Proton Synchrotron. This proposal was discussed and accepted also by all of the Italian physics professors, as is recalled also by A. Rostagni, during the meetings which were held at the Academia dei Lincei for the university syllabus reform, between the end of 1956 and the beginning of 1957. For the moment, however, we have been unable to find the corresponding documents or the papers in which the Consiglio Superiore della Pubblica Istruzione gave its negative reply. This probably happened in the period 1958–62.
- 91) After a long stay abroad, E. Corinaldesi acquired United States citizenship.
- 92) *Graf Bobby, Baron Mucki and Poldi, 123 mal in Wort und Bild*(Fischer Taschenbuch Verlag, Frankfurt am Main, September 1976).
- 93) Victor F. Weisskopf (b. Vienna, 1908), studied theoretical physics at Göttingen (Ph.D. in physics in 1931) and then became assistant of Heisenberg (Leipzig, 1931) and Schrödinger (Berlin, 1932), with periods spent in Copenhagen (with Niels Bohr) and Kharkov, USSR (with L. Landau). In 1933–35 Weisskopf was assistant of Pauli at the Zurich Federal Polytechnic. Later he again worked in Copenhagen, where he remained until 1939, when he moved to Cornell University (Ithaca, NY, USA). In 1943 he was offered a chair at the University of Rochester (N.Y.), but the same year went to Los Alamos, New Mexico, to work on the applications of nuclear energy. From 1945 to 1960 he was a Professor at the Massachusetts Institute of Technology, that he left to become Director General of CERN (1961–1965). After 1965 Weisskopf went back to his MIT chair. He is the author of a wide spectrum of important papers dealing with quantum mechanics, field theory, nuclear physics, and particle physics. He is also the author of a few remarkable books.
- 94) Fernando Amman has pointed out to me that a first mention of e^+e^- rings was made by Bruno at a meeting held in Frascati on 17 February 1960, in the frame of a series of discussions organized by Giorgio Salvini and devoted to the future of the Laboratori Nazionali di Frascati. There still exists a copy of the minutes of the meeting, prepared by Dr. Icilio Agostini, then Administrative Secretary of the Laboratories.
- 95) D.W. Kerst, F.T. Cole, H.R. Crane, L.W. Jones, L.J. Laslett, T. Ohkawa, A.M. Sessler, K.R. Symore, K.M. Terwilliger and Niels Vogt Nilsen, *Phys. Rev.* **102**, 590 (1956) received 26 January 1956. At the beginning of their paper, these authors write: “... The possibility of producing interactions in stationary coordinates by directing beams against each other, has often been considered, but the intensity of beams so far available have made the idea unpractical. Fixed field alternating gradient accelerators offer the possibility of obtaining sufficiently intense beams so that it may now be reasonable to consider directing two beams of approximately the same energy at each other...”
- 96) G.K. O’Neill, *Phys. Rev.* **102**, 1418 (1956), received 13 April 1956. In a footnote O’Neill writes that between the mailing and the publication of his Letter to the *Physical Review* he had become aware that similar suggestions had been made also by W.M. Brobeck of the Berkeley Accelerator Group and by D. Lichtenberg, R. Newton and M. Ross of the MURA Group.
- 97) G.K. O’Neill, “The storage ring synchrotron”, *Proc. CERN Symposium on High-Energy Accelerators and Pion Physics*, Geneva, 1956 (ed.: E. Regenstein) (CERN, Geneva, 1956), Vol. 1, pp. 64–65.
- 98) W.C. Barber, B. Gittelman, G.K. O’Neill, W.K.H. Panofsky and B. Richter, Stanford University Report HEPL 170 (June 1959). This report contains a description of the e^-e^- tangent storage rings and the proposal for its construction in view of an electron-electron scattering experiment as a test of the limits of QED.
- 99) W.C. Barber, B. Gittelman, G.K. O’Neill and B. Richter: “Test of quantum electrodynamics by electron-electron scattering”, *Phys. Rev. Lett.* **16**, 1127 (1966).
- 100) Typical examples are:
- $$\begin{aligned} \gamma + N &\rightarrow N + e^+ + e^- \\ \pi^- + p &\rightarrow N + e^+ + e^- \end{aligned}$$
- 101) Typical examples are:
- $$\begin{aligned} p + N &\rightarrow e^+ + e^- + X \\ p + \bar{p} &\rightarrow e^+ + e^- + X \end{aligned}$$
- 102) S. Drell and F. Zachariassen, *Electromagnetic structure of nucleons* (Oxford University Press, London, 1961), pp. 18, 19.

- 103) L.D. Landau and E.M. Lifschitz, *Sov. Phys.* **6**, 244 (1934), had considered the processes

$$e^+ + e^- \rightarrow e^+ + e^- \text{ or } \begin{cases} e^+ + e^- \\ \mu^+ + \mu^- \end{cases}$$

- in the frame of pure electrodynamics. Processes of this type were later re-examined by F.E. Low [*Phys. Rev.* **120** 582 (1960)], F. Calogero and C. Zemach [*Phys. Rev.* **120**, 1860 (1960)] and later by others: A. Jaccarini, N. Arteaga-Romero, G. Parisi and P. Kessler [*Compt. Rend.* **269B**, 153, 1129 (1969); *Nuovo Cimento* **4**, 933 (1970)]; V.E. Balakin, V.M. Budnev and I.F. Ginzburg [*Zh. Eksp. Teor. Fiz. Pis'ma* **11**, 559 (1970); *JETP Lett.* **11**, 388 (1970)]; S. Brodsky, T. Kinoshita and H. Terazawa [*Phys. Rev. Lett.* **25**, 972 (1970); *Phys. Rev.* **D4** 1532 (1971)]; H. Terazawa [*Rev. Mod. Phys.* **45**, 615 (1973)].
- 104) See, for example: *Proc. Int. Workshop on γ - γ Collisions*, Amiens, 8–12 April 1980 (ed.: G. Cochard) (Springer, Berlin, 1980).
- 105) J. Haissinski, *Expériences sur l'anneau de collisions AdA*, Thèse, Orsay Série A, No. d'ordre 81, soutenue le 5 février 1965.
- 106) C. Bernardini, “La storia di AdA”, *Scientia* **113**, 27 (1978).
- 107) Giorgio Ghigo (b. Turin, 1929–d. Rome, 1968); in 1948 he started to study engineering at the Turin Polytechnic, but some two years later was influenced by Gleb Wataghin to change over to physics, taking his degree in 1953. After a year spent studying cosmic rays in the Turin Section of the INFN, Ghigo joined in September 1954 the Magnet Group of the Accelerator Section of the same Institute. As a highly skilled instrument engineer, he contributed substantially to the design and construction of the magnet for the Italian electron synchrotron, developing various high-quality instruments (flow-meters, magnetometers, quantum-meters, etc.). In 1959 he was appointed Machine Director of the Laboratori Nazionali di Frascati. He then participated in the AdA project and later in ADONE. After moving to Naples for two years he constructed, in 1962, in connection with the research by Edoardo Caianello and Valentino Braitenberg, a completely transistorized machine capable of simulating 100 neurons, the purpose of which was to clarify certain aspects of the functioning of the brain. During the same period he dealt with various other problems of electronic simulation of the structure and/or functioning of the brain. On returning to Frascati he resumed his activities as a skilled instrument engineer, but was suddenly taken ill with an incurable disease and died on 15 March 1968, thereby leaving a serious gap among the researchers of the Laboratori di Frascati, and was sadly missed by all his friends.
- 108) G. Ghigo, “Preliminary discussions on AdA”, Internal Memorandum No. 62, 8 December 1960, Laboratori Nazionali di Frascati del CNEN.
- 109) *Particle Accelerators*, Vol. 3, No. 2, p. 127 (April 1972). The piece of news is reported by John Blewett.
- 110) Deutsches Patentamt, Patentschrift Nr 876279 Klass 21g Gruppe 36, Ausgegeben am 11. Mai 1953: Dr. Ing. Rolf Wideröe, Oslo, ist als Erfinder genannt worden: Aktiengesellschaft Brown, Boveri & Cie, Baden (Schweiz). Anordnung zur Herbeiführung von Kernreaktionen.
- 111) A.P. Aleksandrov, L.M. Barkov, S.T. Belayev, Ya.B. Zel'dovich, B.B. Kadomtsev, A.A. Logunov, M.A. Markov, D.D. Fyutov, V.A. Sidorov, A.N. Skrinski and B.V. Chirikov, “Academician Gersh Itskovic Budker (obituary)”, *Usp. Fiz. Nauk* **124**, 731 (1978).
- 112) E.M. Abramyan et al., “Studies of colliding electron-electron, electron-positron and proton-proton beams at the Institute for Nuclear Physics, the Siberian branch of the USSR Academy of Sciences” (in Russian), in *Proc. Int. Conf. on High-Energy Accelerators*, Dubna, 1963 (Atomizdat, Moscow, 1964), p. 274. [English transl. of Proceedings (USAEC, Oak Ridge, Tenn., 1965), p. 334].
- 113) G.I. Budker, *Sov. Phys. Usp.* **9**, 534 (1966).
- 114) It is in order to notice that at the International Conference on High-Energy Accelerators, held at Brookhaven during the summer of 1961, the Soviet physicists did not appear at the last moment, but their contributions were published and did not contain any mention of possible e^+e^- storage rings, while a report on AdA and a preliminary study on ADONE were presented to the conference, in addition to a paper on the limits to space-charge due to beam-beam effects. When, in 1963, Amman and Bernardini visited Novosibirsk, the ring e^+e^- (VEPP 1) was in operation and VEPP 2 was in the construction stage. Therefore it appears reasonable to conclude that the activity on e^+e^- rings was started after 1961 and no document is known which proves the contrary.
- 115) F. Amman, C. Bernardini, R. Gatto, G. Ghigo and B. Touschek, “Storage ring for electrons and positrons (ADONE)”, Internal Report No. 68 of the Laboratori Nazionali di Frascati, 27 January 1961;

- F. Amman, M. Bassetti, M. Bernardini, G.F. Corazza, L. Mango, A. Massarotti, C. Pellegrini, M. Placidi, M. Puglisi and A. Tazzioli, *Ric. Scient.* 32, Parte 1, 197 (1962).
- 116) A. Blanc-Lapierre, R. Beck, R. Belbeoch, B. Boutouvrie, H. Bruck, L. Burnod, X. Buffet, G. Gendreau, J. Haissinski, R. Jolivot, G. Leleux, P. Marin, B. Milman and H. Zyngier, "Projet d'un anneau de stockage à Orsay pour électrons et positrons d'une énergie maximale de 450 MeV", Rapport CEA No 2363 (LAL 1081), avril 1964.
Also consult the various articles published in: *Symposium International sur les Anneaux de Collisions à Electrons et Positrons*, held at Saclay (Paris) from 26 to 30 September 1966 (eds.: H. Zyngier and E. Cremieu-Alcan) (Presses universitaires de France, Paris, 1966).
- 117) This modification of the CEA, indicated in the literature as a "bypass", presupposes the invention of the so-called "low- β ", made by K. Robinson and G.A. Voss [Cambridge Electron Accelerator Report TM 149 (1965)]. The "bypass" started operation in 1971, but the luminosity never exceeded the value of $2 \times 10^{28} \text{ cm}^{-2} \text{ s}^{-1}$. It was dismantled in 1973. For further overall information, see for example: G. Giacomelli, "High-energy laboratories in the United States", *Giornale di Fisica* 12, 93 (1971).
- 118) R.F. Christy, "Synchrotron beam loss due to quantum fluctuations in the radiation", California Institute of Technology (1957), unpublished.
- 119) M. Sands, "Observation of quantum effects in an electron-synchrotron", California Institute of Technology (1956), presented at the West Coast Meeting of the APS in December 1956.
- 120) C.P. Curtis, A. Galonsky, R.H. Hilden, F.E. Mills, R.A. Otte, G. Parzen, C.H. Pruett, E.M. Rowe, M.F. Shea, D.A. Swenson, W.A. Wallenmeyer and D.E. Young (MURA: Midwestern Universities Research Association), *Proc. Int. Conf. on High-Energy Accelerators*, Dubna, 1963 (Atomizdat, Moscow, 1964), p. 20.
- 121) L.J. Laslett, V.K. Neil and A.M. Sessler, Lawrence Radiation Laboratory Report UCRL 11090 (1963) and *Rev. Sci. Instrum.* 36, 436 (1965). See also: C. Pellegrini and A.M. Sessler, *Sanford Linear Accelerator Center Storage Ring Summer Study*, 1965 (SLAC, Stanford, Calif., 1965), Report SLAC-49, p. 61; E.D. Courant and A.M. Sessler, *ibid.*, p.36.
- 122) F. Bloch and A. Nordsieck, *Phys. Rev.* 52, 54 (1937).
- 123) James Bond, secret agent 007, in a long series of books by Ian Fleming.
- 124) Letter of 21 May 1980.
- 125) According to the law establishing the foundation of the Comitato Nazionale per l'Energia Nucleare (CNEN) valid at the time, the Minister of Industry and Trade was also President of the Consiglio Direttivo of CNEN. This function was fulfilled, during the period of AdA and ADONE, by: the Honourable Emilio Colombo (1960–63), the Honourable G. Togni (1963), Senator Giuseppe Medici (1963–1964), Senator Edgardo Lami Starnuti (1965–1966), the Honourable G. Andreotti (1966–68) and the Honourable Mario Tanassi (1968–69). The Honourable G. Togni was not favourable to CNEN, Senator Lami Starnuti and the Honourable M. Tanassi, differently from the others, showed little interest in the direction of CNEN and in the life and activities of the Laboratori Nazionali di Frascati.
- 126) F. Amman, R. Andreani, M. Bassetti, M. Bernardini, A. Cattoni, V. Chimenti, G.F. Corazza, D. Fabiani, F. Ferlenghi, A. Massarotti, C. Pellegrini, M. Placidi, M. Puglisi, F. Sosò, S. Tazzari, F. Tazzioli and G. Vignola, "Two-beam operation of the 1.5 GeV electron-positron storage ring ADONE", *Lett. Nuovo Cimento* 1, 729 (1969).
- 127) L.M. Brown and F. Calogero, *Phys. Rev. Lett.* 4, 315 (1960);
N. Cabibbo and R. Gatto, *Phys. Rev. Lett.* 4, 313 (1960); *Nuovo Cimento* 20, 185 (1961); *Phys. Rev.* 124, 1577 (1961);
R. Gatto, *Proc. Aix-en-Provence Int. Conf. on Elementary Particles*, 1961 (CEN, Saclay, 1962), Vol. 1, p. 487.
R. Gatto, *Ric. Scient.* 32, Part 1, 161 (1962).
- 128) An overall picture and the way it changed subsequently can be gathered from the following articles from reviews, lectures at summer schools, and papers submitted at the invitation of International Congresses:
M. Grilli, Invited report on "Preliminary results with ADONE", *Proc. Daresbury Study Weekend No. 1 on Vector Meson Production and Omega-Rho Interference*, 12–14 June 1970 (eds.: A. Donnachie and E. Gabathuler) (Daresbury, Nuclear Physics Laboratory, Nr. Warrington, Lancs., 1970) DNPL-R 7, p. 215.
Richard Wilson, Invited report on "Lepton-hadron interactions and quantum electrodynamics", *Proc. 15th Int. Conf. on High-Energy Phys.*, Kiev, August 1970 (Naukova Dumka, Kiev, 1972), p. 219.
G. Salvini, Lectures to the Scuola di Erice on "Electromagnetic production of hadronic resonances", *Elementary*

- processes at high energy* (ed.: A. Zichichi) (Academic Press, New York, 1971), Part A, pp. 322–383.
- M. Conversi, Invited report on “Experiments on electron-positron colliding beams”, *Proc. Daresbury Study Weekend No. 4 on Lepton and Photon Physics in Europe*, 1-3 October 1971 (ed.: A. Donnachie) (Daresbury, Nuclear Physics Laboratory, Nr. Warrington, Lancs., 1971), DNPL-R 19, pp. 87–128.
- C. Bernardini, Invited report on “Results of e^+e^- reactions at ADONE”, *Proc. Int. Symposium on Electron and Photon Interactions at High Energy*, Ithaca, 1971 (Cornell Univ. Lab. Nuclear Studies, Ithaca, 1972), p. 38.
- V. Silvestrini, Invited report on “Electron-positron interactions”, *Proc. 16th Int. Conf. on High Energy Physics*, Chicago-Batavia, 1972 (National Accelerator Laboratory, Batavia, 1972), pp. 1–38.
- G. Salvini, Invited report on “Researches in Frascati on the reactions $e^+e^- \rightarrow e^+ + e^- + X$: The results of the $\gamma\gamma$ group”, at the Int. Colloquium on Photon-Photon Collisions in e^+e^- Rings, 3–4 September 1973, *J. Phys.* C2–C2–8;
- M. Conversi, Invited report on “Experiments with e^+e^- colliding beams”, *Proc. Seminar on ep and ee Storage Rings*, Hamburg, 8–12 October 1973 (Hamburg, 1974), DESY 73–66, pp. 121–172.
- L. Paoluzi, “ e^+e^- colliding beams physics”, *Acta Phys. Polon.* B5, 839 (1974);
- G. Salvini, Seminar on “ e^+e^- physics in Frascati”, Ettore Majorana Center, Erice, July 1974, not published, and address given to the LX Congress of the SIF, Bologna, 1974, not published;
- A. Zichichi, “Why (e^+e^-) physics is fascinating”, *Riv. Nuovo Cimento* 4, 498–532 (1974);
- P. Monacelli and F. Sebastiani, “Recent experimental results in e^+e^- physics and the new particles”, *Riv. Nuovo Cimento* 6, 449 (1976);
- A. Zichichi, “Old and new problems in subnuclear physics”, *Riv. Nuovo Cimento* 6, 529–584 (1976);
- M. Conversi, “ e^+e^- physics”, *Proc. Symposium on Frontier Problems in High Energy Physics*, Pisa, 4–5 June 1976 (Scuola Normale Superiore, Pisa, 1976), pp. 65–88.
- 129) The first verifications of quantum electrodynamics with e^+e^- rings were carried out at Novosibirsk with VEPP 2 [V.A. Sidorov, *Proc. 4th Int. Symposium on Electron and Photon Interactions at High Energy*, Liverpool, 1969 (Daresbury Nuclear Physics Laboratory, Nr. Warrington, Lancs., 1969), p. 22] and at Orsay with ACO [J.E. Augustin et al., *Phys. Lett.* 31B, 673 (1970)]. Shortly after this there were the initial results with ADONE [B. Bartoli, B. Coluzzi, F. Felicetti, V. Silvestrini, G. Goggi, D. Scannicchio, G. Marini, F. Massa and F. Vandi, *Nuovo Cimento* 70A, 603 (1970); B. Borgia, F. Ceradini, M. Conversi, L. Paoluzi, W. Scandale, G. Barbiellini, M. Grilli, P. Spillantini, R. Visentin and A. Malachiè, *Phys. Lett.* 35B, 340 (1971); C. Bacci, G. Penso, G. Salvini, R. Baldini-Celio, G. Capon, C. Mencuccini, G.P. Murtas, A. Reale and M. Spinetti, *Lett. Nuovo Cimento* 2, 73 (1971) on the $e^+ + e^- \rightarrow \gamma\gamma$ processes; C. Bacci, G. Penso, G. Salvini, R. Baldini-Celio, G. Capon, C. Mencuccini, G.P. Murtas, A. Reale, M. Spinetti and B. Stella, *Lett. Nuovo Cimento* 3, 709 (1972) on the process $e^+ + e^- \rightarrow e^+ + e^- + e^+ + e^-$; C. Bacci, G. Parisi, G. Penso, G. Salvini, B. Stella, R. Baldini-Celio, G. Capon, C. Mencuccini, G.P. Murtas, M. Spinetti and A. Zallo, *Phys. Lett.* 44B, 530 (1973) on the process $e^+ + e^- \rightarrow e^+ + e^- + \gamma$; M. Bernardini, D. Bollini, P.L. Brunieri, E. Fiorentino, T. Massam, L. Monari, F. Palmonari, F. Rimondi and A. Zichichi, *Phys. Lett.* 45B, 510 (1973); V. Alles-Borelli, M. Bernardini, D. Bollini, P. Giusti, T. Massam, L. Monari, F. Palmonari, G. Valenti and A. Zichichi, *Phys. Lett.* 59B, 201 (1975)].
- 130) F. Ceradini, M. Conversi, S. D’Angelo, M.L. Ferrer, L. Paoluzi, R. Santonico, G. Barbiellini, S. Orito, T. Tsuru and R. Visentin, *J. Phys. (France)*, Colloque C2, supplément au No 3, Tome 35, p. C2-9 (mars 1974).
G. Barbiellini, S. Orito, T. Tsuru, R. Visentin, F. Ceradini, M. Conversi, S. D’Angelo, M.L. Ferrer, L. Paoluzi and R. Santonico, *Phys. Rev. Lett.* 32, 385 (1974).
- 131) The first results obtained with ADONE by the three groups named “ $\gamma\gamma$ ”, “ $\mu\pi$ ” and the “boson” were submitted by Mario Grilli at the Daresbury Study Weekend in June 1970, and by Richard Wilson to the Kiev Conference in August 1970 (Ref. 131). The first original work on multiple hadron production is by the “boson” group: B. Bartoli, B. Coluzzi, F. Felicetti, V. Silvestrini, G. Goggi, D. Scannicchio, F. Massa, G. Marini and F. Vandi (“boson” group), *Nuovo Cimento* 70A, 615 (1970). More complete results were submitted to the First EPS Conference on Meson Resonances and Related Electromagnetic Phenomena, Bologna, 1971 (Proc.: edited by A. Zichichi, published by Editrice Compositori, Bologna, 1972), by Conversi for the “ $\mu\pi$ ” group (p. 471), by Salvini for the “ $\gamma\gamma$ ” group (p. 481) and Zichichi for the “BCF” group (p. 489). Other original papers, still on this same subject are:
G. Barbarino, F. Ceradini, M. Conversi, M. Grilli, E. Iarocci, M. Nigro, L. Paoluzi, R. Santonico, P. Spillantini, L. Trasatti, V. Valente, R. Visentin and G.T. Zorn (gruppo “ $\mu\pi$ ”), *Lett. Nuovo Cimento* 3, 689 (1972);
C. Bacci, R. Baldini-Celio, G. Capon, C. Mencuccini, G.P. Murtas, G. Penso, A. Reale, G. Salvini, M. Spinelli and B. Stella (gruppo “ $\gamma\gamma$ ”), *Phys. Lett.* 38B, 551 (1972);
M. Bernardini, D. Bollini, P.L. Brunini, T. Massam, L. Monari, F. Palmonari, E. Rimondi and A. Zichichi (gruppo “BCF”), *Phys. Lett.* 44B, 393 (1973); 46B, 261 (1973).
In the review article by Monacelli and Sebastiani (Ref. 128) an account is given of the results of an overall analysis of the Frascati data, made by G. Salvini: a) in a seminar of e^+e^- physics in Frascati, presented to the International School of Subnuclear Physics, Ettore Majorana Center, Erice, July 1974 (unpublished); b) in a talk to the LX Congress of the SIF, Bologna, 1974 (unpublished). Another analysis of the results of the BCF group is given by Zichichi in his article dated 1974 (Ref. 128).
- 132) For a detailed examination of these problems, see, for example: R.P. Feynman, “Photon-hadron interactions”, in *Frontiers in physics* (W.A. Benjamin Inc., Reading, Mass., 1972).

- 133) For the WAEP (wide angle electron pairs) see:
 R. Richter, *Phys. Rev. Lett.* 1, 114 (1958); R.B. Blumenthal, D.C. Ehn, W.L. Faissler, P.M. Joseph, L.J. Lanzerotti, F.M. Pipkin and D.G. Stairs, *Phys. Rev.* 144, 1199 (1966); E. Eislander, J. Feigenbaum, N. Mistry, P. Mostek, D. Rust, A. Silverman, C. Sinclair and R. Talman, *Phys. Rev. Lett.* 18, 425 (1967); J.C. Asbury, W.K. Bertram, U. Becker, P. Joos, M. Rhode, A.J.S. Smith, S. Friedlander, C.L. Jordan and S.C.C. Ting, *Phys. Rev.* 161, 1344 (1967).
 For the WAMP (wide angle muon pairs) see:
 A. Alberigi Quaranta, M. De Pretis, G. Marini, A. Odian, G. Stoppini and L. Tau, *Phys. Rev. Lett.* 9, 226 (1962); J.K. De Pagter, A. Boyarski, G. Glass, J.I. Friedman, H.W. Kendall, M. Gettner, J.I. Larrabee and R. Welstein, *Phys. Rev. Lett.* 12, 739 (1964); J.K. De Pagter, J.I. Friedman, G. Glass, R.C. Chase, M. Gettner, E. von Goeler, R. Weinstein and A.M. Boyarski, *Phys. Rev. Lett.* 17, 767 (1966); D.J. Quinn and D.M. Ritson, *Phys. Rev. Lett.* 20, 890 (1968).
- 134) The discovery of the J/ψ particle was announced in the papers published on 2 December 1974 by *Phys. Rev. Lett.*, by the MIT Group, led by C.C. Ting, who had observed at the AGS of the Brookhaven National Laboratory a very strict resonance at 3.1 GeV in the $p + p \rightarrow J \rightarrow e^+ + e^-$ process, and by the SLAC Group, headed by B. Richter, who had observed at SPEAR the same resonance in the process $e^+ + e^- \rightarrow \psi \rightarrow e^+ + e^-$. In the same issue of *Phys. Rev. Lett.* a confirmation of this discovery is given by a super-group of the Laboratori Nazionali di Frascati, which had learnt, by a telephone conversation with Ting, of the existence of this resonance, and which had modified slightly the operation mode of ADONE in order to observe it, since the latter was slightly above the energy range for which the Frascati machine had been designed. The index of the issue of *Phys. Rev. Lett.* of 2 December 1974 (Vol. 33, No. 23) is as follows:
 “Experimental observation of a heavy particle J^0 ”: J.J. Aubert, U. Becker, J.P. Biggs, M. Chen, G. Everhart, P. Goldhagen, J. Leong, T. McCarriston, T.C. Rhoades, M. Rhode, Samuel C.C. Ting, Sau Lan Wu and Y.Y. Lee: p. 1404.
 “Discovery of a narrow resonance in e^+e^- annihilation”: J.-E. Augustin, A.M. Boyarski, M. Breidenbach, F. Bulos, J.T. Dakin, G.J. Feldman, G.E. Fischer, D. Fryberger, G. Hanson, B. Jean-Marie, R.R. Larsen, V. Lüth, H.L. Lynch, D. Lyon, C.C. Morehouse, J.M. Paterson, M.L. Perl, B. Richter, P. Rapidis, R.F. Schwitters, W.M. Tanenbaum, F. Vannucci, G.S. Abrams, D. Briggs, W. Chinowsky, C.E. Friedberg, G. Goldhaber, R.J. Hollebeek, J.A. Kadyk, B. Lulu, F. Pierre, C.H. Trilling, J.S. Whitaker, J. Wiss and J.E. Zipsce: p. 1406.
 “Preliminary result of Frascati (ADONE) on the nature of a new 3.1 GeV particle produced in e^+e^- annihilation”: C. Bacci, R. Baldini-Celio, M. Bernardini, G. Capon, R. Del Fabbro, M. Grilli, E. Iarocci, L. Jones, M. Locci, C. Mencuccini, G.P. Murtas, G. Penso, G. Salvini, M. Spano, M. Spinetti, B. Stella, V. Valente, B. Bartoli, D. Bisello, B. Esposito, F. Felicetti, P. Monacelli, M. Nigro, L. Paoluzi, I. Peruzzi, G. Piano Mortari, M. Piccolo, F. Ronga, F. Sebastiani, L. Trasatti, F. Vanoli, G. Barbarino, G. Barbiellini, C. Bemporad, R. Biancastelli, M. Calvetti, M. Castellano, F. Cevenini, F. Costantini, P. Lariccia, S. Patricelli, P. Parascandolo, E. Sassi, C. Spencer, L. Tortora, U. Troya and S. Vitale: p. 1408 (1649E).
- 135) For an overall picture of these new particles, see the various invited reports published in *Proc. 1977 Int. Symposium on Lepton and Photon Interactions at High Energy*, Hamburg, 25–31 August 1977 (DESY, Hamburg, 1977), and G. Feldman, invited report on “ e^+e^- annihilation”, *Proc. 19th Int. Conf. on High Energy Physics*, Tokyo, 23–30 August 1978 (Physical Society of Japan, Tokyo, 1979), pp. 777–789.
- 136) S. Glashow, J. Iliopoulos and L. Maiani, *Phys. Rev. D* 2, 1285 (1970).
- 137) M. Conversi, T. Massam and A. Zichichi, *Nuovo Cimento* 40A, 690 (1965).
- 138) A. Zichichi, S.M. Berman, N. Cabibbo and R. Gatto, *Nuovo Cimento* 24, 170 (1962).
- 139) R.R. Wilson, “The next generation of particle accelerators”, *Sci. Am.* 242, 26 (1980).
- 140) C. Bernardini, “Colliding beams in the future”, *J. Phys. (France)*, Colloque C2, Supplément au No 2, Tome 37, p. C2–67 (février 1976).
- 141) The Matteucci Medal has been awarded on some forty occasions, starting in 1870. Among the award winners were: A. Righi (1882), K. Röntgen (1896), H. Poincaré (1905), P. Zeeman (1912), A. Einstein (1921), N. Bohr (1923), E. Fermi (1926), W. Heisenberg (1929), F. Rasetti (1931), I. and F. Joliot (1932), W. Pauli (1956).
- 142) L. de Broglie, *Compt. Rend.* 195, 862 (1932); 197, 536 (1932).
- 143) P. Jordan, *Z. Phys.* 93, 464 (1935).
- 144) M.H.C. Pryce, *Proc. Roy. Soc. Ser. A* 165, 247 (1938).
- 145) S.A. Bludman, *Nuovo Cimento* 27, 751 (1963).

- 146) B. Ferretti, *Nuovo Cimento* 33, 264 (1964); see also: B. Ferretti and G. Venturi, *Nuovo Cimento* 35, 644 (1965).
- 147) For example, when speaking of himself, in those years, he would often say he was the “shit-pump mantenuto” referring to the Garvens pumps (see Section 5) which were used some time for cesspools.
- 148) This last convergence was based, however, on experimental data, completely outdated now, but that at the time seemed to indicate a linear increase of R with s . Such an increase is clear in the data presented by B. Richter [“Plenary Report on $e^+e^- \rightarrow$ hadrons”, *Proc. 17th Int. Conf. on High Energy Physics*, London, July 1974 (Rutherford Laboratory, Chilton, Didcot, 1974), p. IV-37]. It was due, as it was understood later but was already suspected then (see, for example, B.H. Wiik, “Parallel session on e^+e^- interactions”, p. IV-1 of the same volume), to the (unresolved) J/ψ and to its radiative tail and, in minor part, to the threshold of the “charm”.
- 149) H. Thirring, *Z. Phys.* 19, 33 (1918); 22, 29 (1921).
- 150) L. Pietronero, “On rotating reference systems in Einstein’s theory of gravitation”, Internal Memorandum No. 337, 29 September 1971, Istituto di Fisica Guglielmo Marconi, University of Rome.
- 151) L. Pietronero, “The mechanics of particles inside a rotating cylindrical mass shell”, *Ann. Phys. (USA)* 79, 250 (1973).
- 152) L. Pietronero, “Gravitational interpretation of the centrifugal and Coriolis force”, *Istituto di Alta Matematica, Symposia Mathematica* 12, 57 (1973); “Mach’s principle for rotation”, *Nuovo Cimento* 20B, 144 (1973).
- 153) Felice Ippolito (b. Naples, 1915), Professor of Applied Geology at the University of Naples, and Secretary General of the CNEN since its foundation, was accused in 1963 of administrative irregularities and prosecuted. The heavy sentence which he received was mainly on account of breaches due to “oversights”. In reality, they concerned administrative measures decided by the Commissione Direttiva of the CNEN, presided by the Honourable Emilio Colombo, Minister for Industry and Commerce, and of which I myself was a member. These measures were essential either in order to comply with the undertaking which the Italian Government had made with respect to EURATOM, or in order to complete the CNEN programmes within the prescribed time scale. The repercussions of the Ippolito Case are easy to grasp: in 1963 Italy had begun to become a fairly advanced country in the use of nuclear energy. Today, in 1980, it is certainly one of the lowest on the list.
- 154) Between the 10 and 17 of August 1963, Giuseppe Saragat published, via a press agency, four critical articles concerning Italy’s nuclear policy and the management of the CNEN, which led to the Ippolito Case and to the partial paralysis of the Italian Nuclear Organization. The visit paid by Saragat to the CERN Laboratories in Geneva on 27 August 1963 was intended to show that his position in regard to the development of the energy applications of nuclear physics had nothing to do with his interest in fundamental research. The four articles by Saragat and his statements issued at CERN were published by his followers and admirers in a booklet entitled *Putting nuclear policy into order* (Editoriale Opere Nuove, 1963), which is still very interesting to read.
- 155) Domenico Marotta (1886–1974), a chemist, who conceived and founded the Istituto Superiore di Sanità (ISS), which he directed with extreme broadmindedness and understanding of scientific, health, and organizational problems between 1935 and 1961. In 1965 he was prosecuted for some very minor administrative irregularities, which solely concerned certain formal aspects of his management of the ISS. This legal action embittered the final years of his life, even though the majority of his colleagues did not fail to show their unswerving respect and admiration [see D. Bovet, “Domenico Marotta”, *Celebrazioni Lincee* 91 (1975); G.B. Marini Bettolo, “Domenico Marotta”, *Commentarii Pontificia Academia Scientiarum*, Vol. 3, No. 12 (1975)]. Giordano Giacomello (1910–1968), Professor of Pharmaceutical Chemistry at the University of Rome from 1948 onwards, and author of a considerable number of scientific works, replaced Marotta in 1961 as Director of the ISS. Even more unjustly and unjustifiably he too was involved in the same legal action and, griefstricken, died shortly after the sentence [see G.B. Marini Bettolo, “Giordano Giacomello”, *Celebrazioni Lincee* No. 43 (1971)].
- 156) List of lectures recorded on video tape, from the programme “Living Science”
- (1)—B. Touschek, *The birth of the quantum* (2/4/1975)
 - (2)—E. Amaldi, *The neutron* (9/4/1975)
 - (3)—P.A.M. Dirac, *The story of the positron* (15/4/1975)
 - (4)—G. Careri, *From the atomic hypothesis to Bohr’s atom* (30/4/1975)
 - (5)—E. Segrè, *The chemical elements* (7/5/1975)
 - (6)—R. Wideröe, *History and principles of high-energy accelerators* (28/5/1975)
 - (7)—B. Touschek, *Comments on R. Wideröe’s lecture* (31/7/1975)
 - (8)—E. Bombieri, *Classification of surfaces* (22/5/1975)
 - (9)—M. Caputo, *Applications of elasticity theory to the study of earthquakes* (4/6/1975)
 - (10)—G. Colombo, *Review of current investigations into the solar system* (11/6/1975)
 - (11)—T. Regge, *Superfluidity* (18/6/1975)

- (12)—G. Sansone, *Certain developments in the theory of ordinary differential equations over the last fifty years* (18/12/1975)
- (13)—G. Bernardini, *Matter and antimatter: conceivable symmetries and objective reality* (17/12/1975)
- (14)—E. Picasso, *Measurements of the anomalous moment of the electron and muon* (16/1/1976)
- (15)—B. Segre, *An approach to the four-colour problem* (12/2/1976)
- (16)—M. Conversi, *The mu meson* (11/2/1976)
- (17)—A. Carrelli, *The symmetries in classical physics* (13/2/1976)
- (18)—B. Touschek, *The harmonic oscillator* (25/2/1976)
- (19)—V. Telegdi, *The P, C, T symmetries in atomic and particle physics* (24/4/1976)
- (20)—T. Regge, *The method of dimers in statistical mechanics* (5/5/1976)
- (21)—G. Chiarotti, *The Volta effect and the battery* (7/2/1977)
- (22)—B. Touschek, *On restricted relativity*
 1—*The pre-history of the theory* (17/5/1977)
 2—*Relativistic kinematics* (19/5/1977)
 3—*Relativistic dynamics* (24/5/1977)
- (23)—L. Pietronero, *On the gravitational constant* (24/5/1977)
- 157) S. van der Meer, CERN ISR-Po/72-31, “Influence of bad mixing on stochastic acceleration”, CERN SPS/DI/PP/Int. Note 778; “Design study of a proton-antiproton colliding beam facility”, CERN/PS/AA 78-3; “Stochastic cooling theory and devices”, *Proc. Workshop on Producing High Luminosity High Energy Proton-Antiproton Collisions*, Berkeley, 27–31 March 1978 (LBL, Berkeley, Calif., 1978), LBL 7574: Conf. 780345, p. 73.
- 158) “Batik” is a local form of art of the inhabitants of Java, in which cotton materials are coloured with various designs. The drawing (Javanese: *batik* = point or drawing) is made with liquid wax on a white background. The material is then immersed in a bath of dye, and when the layer of wax is removed with boiling water the pattern stands out against the coloured background.
- 159) Ludwig Wittgenstein (b. Vienna, 1889 – d. 1951). After having frequented the Technische Hochschule in Berlin in order to study engineering, he dedicated himself to mathematical logic, fundamental problems of arithmetic, and philosophy of science. Initially he was strongly influenced by the works of Frege and Russell, from whom he later completely separated on philosophical views. His most famous works are: *Tractatus Logico-Philosophicus* [edition in German and English, with an introduction by Bertrand Russell (Kegan Paul, Trench, Trubner and Co., London, 1922)], which he wrote in his early years, and his posthumous work *Philosophische Untersuchungen* [English transl. by C.E.M. Anscombe: *Philosophical investigations* (Basil Blackwell, Oxford, 1953)]. He was primary school teacher in Austria and University Professor in England, musician, and architect. Although he was not a member of it, he was one of the main inspirers of the “Vienna Circle”.
- 160) For example, Karl Kraus, *Briefe an Sidonie Nadherny von Borutin (1913–1936)* (Deutscher Taschenbuch Verlag, Munich, 1977), Vols. 1 and 2.
- 161) Hans Weigel, *Karl Kraus oder Die Macht der Ohnmacht* (Deutscher Taschenbuch Verlag, Munich, 1972). Werner J. Schweiger, *Das Grosse Peter Altenberg Buch* (Paul Zsolnay Verlag, Vienna-Hamburg, 1977).
- 162) C.M. Nebe Hay, *Gustav Klimt: sein Leben nach zeitgenössischen Berichten und Quellen* (Deutscher Taschenbuch Verlag, Munich, 1976).
- 163) Karl Kraus, “Sprüche und Widersprüche (1909)” in *Beim Wort genommen* (Munich, 1955).
- 164) **Note added in proof:** Gerhard Schumann (b. Dresden 1911) studied in Halle and Leipzig, where he worked with Smekal on the mechanical resistance of glasses under traction. In 1950 he moved to Heidelberg where he worked under O. Haxel. Later he studied the “fall out” by means of the filter method and became an expert in the exchange phenomena in the atmosphere.