In the above table are given the monthly and annual rainfall figures for the three rain-guages in Cherrapunji along with its co-ordinates, height above sea-level and the length of record. The same figures for Waialeale in Kauai Island (as far as available) and Debundja in Nigeria are also tabulated.

Waialeale, Kauai Island, Hawaii territory, according to data in *Climate and Man*, a publication of the United States Department of Agriculture, has an average annual total rainfall of 460 inches. No monthly figures are available and the average is based on data of 20 years only. This average, however, is not supported by the data of annual rainfall for the years 1912 to 1930, given in *Heavy Rainfall Records*, by Jhon R. Theman. The figures for Waialeale are reproduced in the table in the previous column.

MT. WAIALEALE (Hawaii Territory)

Year		Rainfall in inches
1912	..	414·00
1913	..	451·00
1914	..	—
1915	..	—
1916	..	521·00
1917	..	—
1918	..	—
1919	..	204·00
1920	..	549·00
1921	..	367·00
1922	..	452·00
1923	..	360·00
1924†	..	228·00
1924–25*	..	362·40
1925–26*	..	219·60
1926–27*	..	403·24
1927–28*	..	—
1928–29*	..	354·22
1929–30*	..	301·95

* From July 1 to July 1.
† Records of six months.

In view of the foregoing and also the much longer period of 38 years on which the average of the rainfall at the Welsh Mission House, Cherrapunji, is based, it may be taken that the rainfall of Cherrapunji is higher than that of Waialeale.

With regard to other places having high rainfall it may be noted that Mawsynram, a station near Cherrapunji, has records of a few years which show that it has a rainfall of well over 400 inches. No average is given as the period of data is short.

The only other station known, which has an annual rainfall of 400 inches or over is Debundja in Nigeria. Its average annual rainfall based on data of fourteen years only is 400 inches.

From the above it appears that Cherrapunji receives the heaviest rainfall in the world. Next to Cherrapunji and Mawsynram, the places of heaviest rainfall seem to be Waialeale and Debundja.

I wish to express my great indebtedness to the Deputy Director-General of Observatories, India Meteorological Department, for kindly helping in elucidating this important matter.

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NEW METHODS OF PRODUCING HIGH ENERGY PARTICLES

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THE extension of our knowledge in respect of the meson and the short-range forces inside the atomic nucleus awaits the development of laboratory techniques accelerating charged particles to cosmic-ray energies. The relativistic increase in mass leading to a change in frequency sets an upper limit to the energy of a well-defined beam of ions in the cyclotron. Devices which give promise of attaining energies in excess of 200 Mev. are the (1) betatron, (2) synchrotron, (3) relativistic cyclotron, (4) microtron, (5) linear resonance accelerator and (6) linear wave guide accelerator. The first four bring about resonance acceleration in a steady or varying magnetic field and the last two make use of micro-waves.

The induction electron accelerator called the *betatron* was perfected by Kerst.[1] A stream of electrons shot tangentially into a toroidal vacuum chamber placed between the pole-pieces of an A.C.-fed electromagnet gets accelerated in the electric field induced by the changing magnetic field. Decrease of the field with the radius gives rise to magnetic focussing, resulting in a fine output beam. The magnet of the 100 Mev. betatron built by the G.E. Co. at Schenectady weighs 130 tons, has a pole-face of 16 inch diam., and is fed by a 60 cycle A.C. at a full load of 200 KW. Although it may be possible to raise the energy to 500 Mev. by proper adjustment of the time dependance of the field, the loss of energy by radiation will be considerable at the higher energies.

The *synchrotron* due to Veksler[2] and McMillan[3] uses a time-varying magnetic field as in the betatron and a split thin-walled dee system connected to a high voltage generator as in the cyclotron. The inherent phase stability of the orbits brings about automatic synchronisation and makes up for moderate energy losses. When accelerating heavy particles, the damping of the phase oscillation set up by the radial displacement of the orbit may be compensated by motor-driven tuning devices. If the radiation loss per turn can be reduced in respect of the amplitude of the dee voltage, 1000 Mev. energies may possibly be reached. The Metropolitan-Vickers have under construction a 300 Mev. electron synchrotron and the Birmingham University a proton synchrotron.

Relativistic cyclotrons producing ions of energy more than 200 Mev. can be constructed if the problem of space and time variation of the magnetic field are solved satisfactorily. Arrangements are in progress to convert the 184-inch Berkeley cyclotron into a frequency modulated instrument (synchrotron cyclotron). It is expected that a dee voltage of only 50 kV. will be able to generate one micro-ampere of 200 Mev. deuterons.[4]

The *microtron* is an electron cyclotron where the particles are made to slip one cycle of phase in each circuit. A micro-wave resonator located near the edge of a uniform magnetic field gives rise to the necessary electric field. The use of a split magnet and several resonant cavities in series worked by a single power source is suggestd by Schwinger to compensate for the drift in the orbits. The short acceleration time of the electrons makes the radiation loss negligible and the large separation of the orbits facilitates the easy removal of the output beam. Electrons of 1000 Mev. energy can be produced if defocussing can be counteracted by proper shaping of the magnetic field or by the insertion of a loosely coupled parallel series of resonators.

The *linear resonance accelerator* uses an array of high Q resonators operated at a metre wave-length and pulsed simultaneously. When used for accelerating ions, a loosely coupled coaxial line, driven by a master oscillator and loaded suitably, may be employed to phase the system. Radiation losses are at a minimum and the equipment is inexpensive compared to the magnetic devices. A 450-metre long system may be needed to generate 300 Mev. electrons. The *linear wave guide accelerator* developed in the M.I.T. Radiation Laboratory consists of an array of tightly coupled resonators operated from a single oscillator. If difficulties connected with the accurate construction of wave guide sections to avoid the propagation of unwanted modes and the provision of an automatic tuning to overcome temperature and other variations are successfully tackled, it may be possible to speed up electrons to 1000 Mev. energy. A detailed discussion of the working and possibilities of the new devices is given by Schiff.[5]

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WHAT IS MASS?

BY D. FERROLI, S.J., D.SC.

1. *Tentative Definition.*

IN text-books which are very widely used, we find the mass of a body defined as "the quantity of matter it contains".

Matter is tentatively defined as "that which can be perceived by the senses" (*confr.* Loney, *Dynamics of a Particle*, pp. 4-5).

Hence, colour, sound, electricity, magnetism would presumably come under the *genus* "Matter". I wonder whether many would agree to this. Another definition is: "Matter is that which can be acted upon by, or exert force".

So matter would be both active and passive, under different circumstances. Could perhaps, matter, under its active aspect ("that which can exert force") be identified with energy?

The author in question is aware of the imperfection of his definition, for he adds: "Matter, like time and space, is a primary conception, and hence it is practically impossible to give it a precise definition".

2. *Mass under a triple aspect.*

As the student advances, he meets the concept of mass under three aspects:

(*a*) From the first fundamental equation of Dynamics: Force = Mass × Acceleration, one would deduce that mass is a *coefficient of inertia*, it is something passive, something which, in a way, tends to resist acceleration.

(*b*) In the second fundamental equation of Dynamics: Mass × Velocity = Acceleration × Time, the mass assumes a slightly different connotation; it is a *capacity of impulse*, it is something which contributes to the momentum of a body. The contribution, however, does not seem merely passive, but active, as a man who tries to stop a roller or a cricket ball, would experience.

(*c*) Finally in the equation of energy E = Half the mass by the square of velocity, the mass is a capacity of *kinetic energy*—not energy really, but something that can be energised, invested, so to say, with energy. The passive aspect of mass is again prominent.

3. *Mass in Relativistic Mechanics.*

In Relativistic Mechanics the above three definitions of mass do not give the same values. In fact, even before Einstein, one met in Higher Mechanics the Maupertuisian Mass, the Hamiltonian Mass and the Leibnitzian Mass.*

The present writer has dealt at length with their conceptual significance in his *Madras University Lectures* (March 1927), which were published by the University in 1929. Here it may be sufficient to point out that:

(*a*) If mass is a *coefficient of inertia* then it is necessary to consider two masses: *the longitudinal* mass, when the force is parallel to the velocity; and the *transversal mass*, when the force is

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* Of which the Maupertuisian mass is the mean of the Hamiltonian and the Leibnitzian masses.