Stacked Injector Rings Planned for CERN PS

An improved injector for the CERN 28-GeV proton synchrotron is expected to increase its maximum proton flux by a factor of ten to 10^{13} protons per pulse. The repetition rate will also be increased to one per second, with a new magnet power supply, by a factor of between 1.5 and 3 depending on the energy.

The new injector will consist of four 800-MeV synchrotron rings, with a total circumference equal to that of one turn of the proton synchrotron, stacked pancake fashion alongside the big ring (figure). These slow-cycling, strong-focusing rings will share common magnets with four gaps to each magnet. They will be fed by the existing 50-MeV linear accelerator, which is to be improved, and will eject their 800-MeV protons sequentially into the main ring so that one complete turn will be filled on each cycle. Helmut Reich, in charge of the new booster program, told PHYSICS TODAY that this injection process is expected to raise the space-charge limit on beam intensity in the proton synchrotron by a factor of ten without any corresponding increase in the angular divergence of the beam; experiments with small external targets will therefore receive the full benefit of the improved intensity.

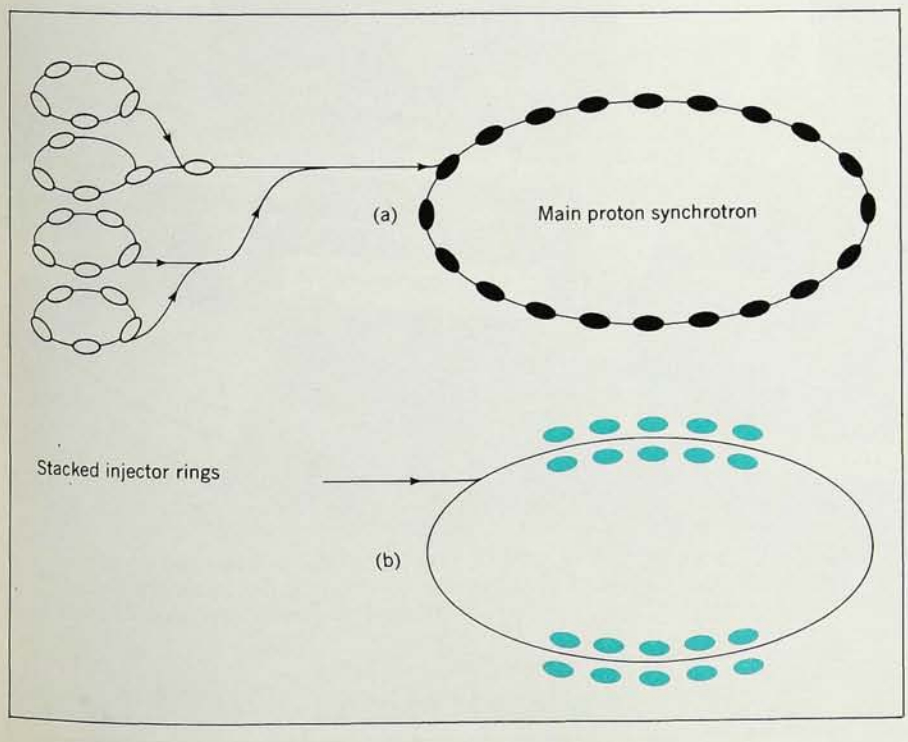
Alternatively the four booster rings can be grouped into two pairs so that their total pulse of protons can be injected into only one half, or even one quarter, of the main accelerator ring. It is expected that bunching the pulse like this will improve the interaction rate in the intersecting storage rings now under construction (PHYSICS TODAY, February 1966, page 66).

A study of the likely radiation problem with these improvements suggests that the design peak intensity from the booster will not be continuously usable; the limit on the extracted beam at 25 GeV is expected to be 3×10^{12} protons per sec.

The magnet power supply improvements should be completed by the middle of this year; the new booster rings will take five years to build after authorization is obtained.

Other new equipment for the CERN proton synchrotron include a French heavy-liquid bubble chamber for neutrino physics and a proposed 3.5-meter hydrogen bubble chamber to be built by CERN, France and Germany.

NEW INJECTION SYSTEM for CERN 28-GeV proton synchrotron. The four stacked rings (left) can be switched to inject either sequentially to fill the main ring completely (a) or in two groups to fill half of the ring at double intensity (b).



Pulsed Radio Sources May Be Neutron Stars

At least three radio observatories have recently reported an entirely new type of radio source that emits pulses with extremely stable repetition frequency and apparently random amplitude. It is tempting to identify these sources as neutron stars, postulated but not yet observed, or as white dwarf stars. Observations with optical telescopes are under way to look for visible radiation from these sources and to see whether the same pulsation occurs.

The discovery was made by a group (A. Hewish, S. J. Bell, J. D. H. Pilkington, P. F. Scott and R. A. Collins) at the Mullard Observatory of Cambridge University by the method that is becoming traditional for advances in radio astronomy—tracking down an annoying source of interference. The "interference" detected with their new 470 × 45-meter antenna array turned out to be coming from a fixed point in the sky, therefore not terrestrial, and to consist of pulses whose repetition frequency, 1.3373 seconds, stays constant to better than one part in 10^7. A search for similar sources soon turned up three others, and the observations, started last September, were reported in *Nature*, 24 Feb. On 28 March, at a University of Virginia symposium, Hewish released the coördinates of these other three sources and proposed the names "Pulsar" 1,2,3 and 4 for those so far discovered.

Sir Martin Ryle and Judy Bailey, also of Cambridge, wrote in *Nature*, 9 March, that they had established a more accurate position of the original source with different instrumentation, and they made a tentative identification of the radio source as an 18th magnitude blue star on a Palomar

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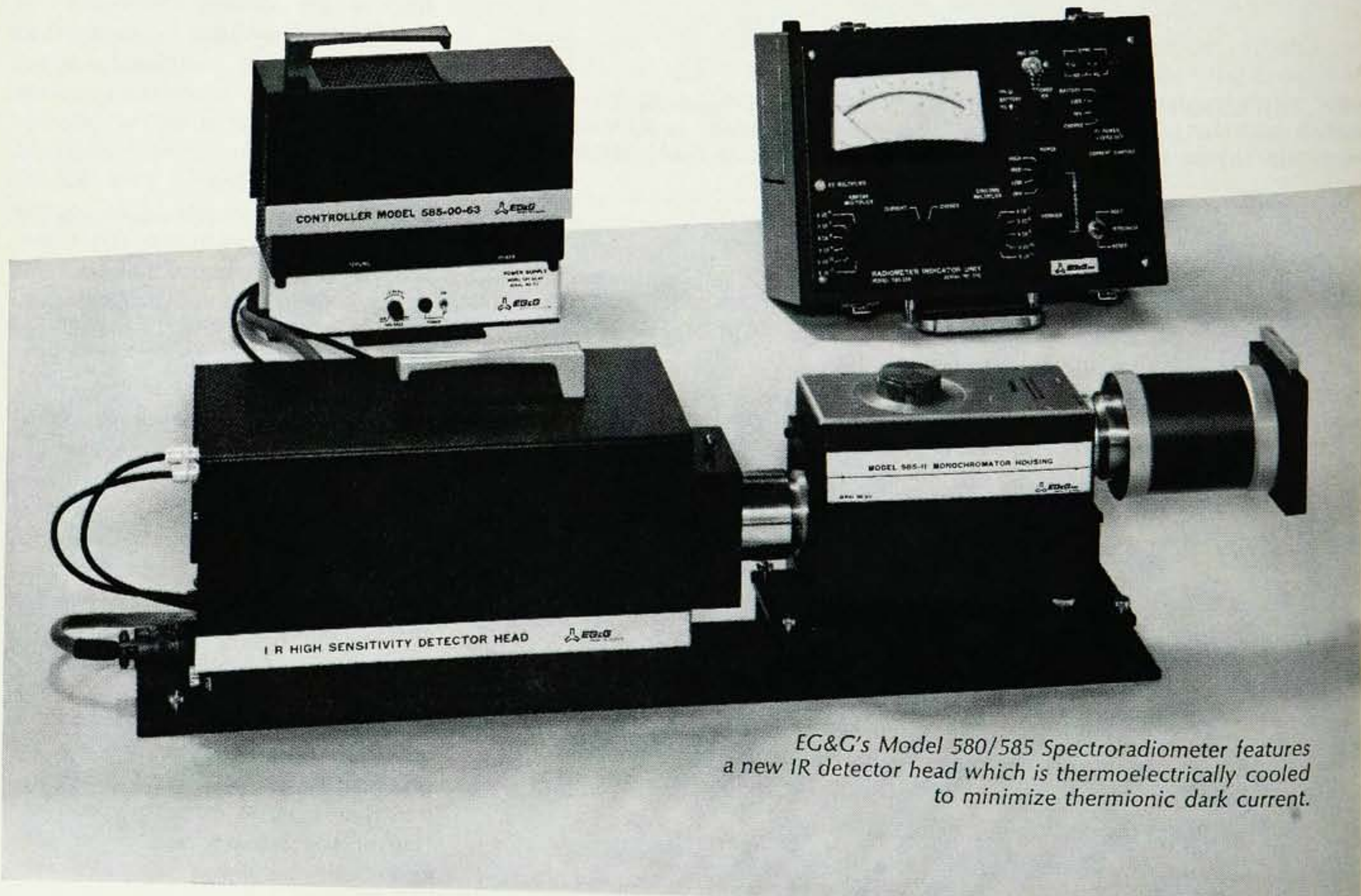

EG&G's Model 580/585 Spectroradiometer features a new IR detector head which is thermoelectrically cooled to minimize thermionic dark current.

Sky Survey print. In the same issue of *Nature* a group (J. G. Davies, P. W. Horton, A. G. Lyne, B. J. Rickett and F. G. Smith) at Jodrell Bank reported that random fine structure, with periods at least as short as 1 msec, is present in the pulses.

Observations of the original source are being made also at Arecibo, and all the findings of the British groups have been confirmed.

Signals have been received by these four groups at a total of six different frequencies, from 81.5 to 1407 MHz. Short pulses are detected because the emission frequency sweeps downward on each cycle and registers as a pulse whenever the frequency passes through the receiver's passband. Dispersion of a wide-band signal in the interstellar medium could produce this effect, just as radio "whistlers" are dispersed during propagation in the earth's atmosphere—higher frequencies travel faster. The pulse amplitude changes irregularly, but with a four-minute pattern; signals are only received during about one minute in four. Amplitude variations of longer time scale show up in records covering six months.

Because there is no detectable parallax as the earth moves in its orbit we know that the radio source is more than 1000 AU away, well outside the solar system. If the frequency sweep is indeed a result of dispersion during transmission we can put an upper limit on the distance at 65 parsec. The size of the emitter can be estimated, from the rapidity of pulses, to be not greater than 5000 km.

Neutron star? Stable oscillations of white-dwarf stars or neutron stars are a possible explanation for these signals. White dwarfs are elderly stars that have exhausted their energy resources and have collapsed to small sizes and high densities; neutron stars were postulated as an alternative development where greater densities force protons and electrons together as neutrons. A. G. W. Cameron (Yeshiva University) suggested that neutron stars may also arise as supernova remnants, when pulsation is likely. But the observed period of 1 sec is too slow for the densities expected in a neutron star and too fast for the fundamental frequency of a white dwarf. The Cambridge astronomers find agreement between their observations and the predictions if they assume a neutron star with a density 10^{13} g/cm^3, but Kip Thorne (U. of Chicago) argues in the April *Astrophys. J. Letters* that this density corresponds to an energetically-unbound neutron star that could probably not be formed by the natural process of stellar evolution. Thorne believes that unstable nuclear burning in the envelope of a white dwarf excites harmonic modes rather than the fundamental, and these harmonics have periods between 0.2 and 20 sec.

Polarized Gamma Rays Made by Compton Scattering

Two laboratories, at Tufts University and the Lebedev Institute in Moscow, have simultaneously developed a novel production mechanism for very high-energy gamma rays. Photons in a laser beam are Compton scattered off relativistic electrons in an accelerator. The method is likely to be of particular value because the gamma rays are produced with the same polarization properties as the incident laser light, and nearly 100% plane- and circular-polarized beams will be available for tests of T invariance in electromagnetic interactions and other high-energy physics experiments.

In a head-on electron–photon collision the photon energy, say 2 eV, is Doppler shifted into the x-ray region from the point of view of an electron travelling at close to the velocity of light. Back-scattered photons must be Doppler shifted again to yet higher energy when observed in laboratory coördinates, and the combined effect is that laser photons become gammas of MeV and GeV energies. The output energy varies approximately as the square of electron energy.

At the Cambridge Electron Accelerator Richard Milburn (Tufts University) has used a small 0.2-joule

SOURCE OF HIGH-ENERGY GAMMA RAYS at the Cambridge Electron Accelerator. Light from a ruby laser is reflected at a quartz mirror to meet 6-GeV electrons in a straight section of the machine. Backscattered gammas pass through the mirror and are counted in a total-absorption Cerenkov counter.