LETTERS *Continued from page 3*

mental Theory" forms, for those disinclined to believe it, a worthy object for disproof.

C. W. KILMISTER
E. W. BASTIN

Queen Mary College
London, England

More Physics Tomorrow

Sir:

The editor's recent invitation to indulge in unbridled speculation coupled with Professor Gamow's concurrently presented example of the art ("Any Physics Tomorrow?") have prompted the following presentation of a case which seems to show that we shall certainly have plenty of problems for physics tomorrow and perhaps even for the day after. When there is mention of the convergence of the field of physics, it is very tempting to brush it off by reciting the usual stories of the attempt to close the Patent Office in 1840 because everything possible had then been invented, and the statement attributed to a famous physicist at the turn of the century that all the basic principles of physics had then been discovered and that the only further work lay in the improvement of measurements.

In considering the problem on a basis of precedent, one could also mention a number of skeletons now hanging in the closet of the natural philosopher such as the caloric theory of heat, the ether medium, or the phlogiston theory of oxidation, and one could show that the very improvement in accuracy of measurement mentioned above had more than once resulted in revolutionary changes such as the introduction of quantum theory. Most such changes have so far introduced a divergence rather than a convergence of the field.

A study of these historical events, however, cannot give any assurance of the future, because the historical series is too short to allow an accurate extrapolation. A better case can be found in an examination of the methods used in "discovering" a new constant, a basic principle, or a fundamental particle.

Let us commence with the basic assumption necessary to all operational sciences that a reasonably orderly universe exists, independent of our power to observe it or to predict its operations and let us say that its state can be represented by the statement of a multitude of independent quantities. On this basis we may represent the state of the universe by a point or a small region in a multi-dimensional mathematical space and we may regard the progress of the universe from state to state as a motion of the representative point.

If we were gifted with omniscience, the shape of the multi-dimensional surface or the nature of the probability density (depending on whether the point moves randomly or not) would be immediately clear to us, and physics

Continued on page 38

LETTERS *Continued from page 5*

would indeed converge. Since we are capable of only limited perceptions, and since our ability to handle vast numbers of dimensions is not great, our effort in scientific investigations of all types is to erect approximate frameworks in the multi-dimensional space which predict the performance of the observed universe. These may eventually surround the multi-dimensional surface as scaffolding surrounds a skyscraper, touching here and there, but deviating considerably at many points. In seeking to "discover" a new fact of the universe and fit in a new piece of the scaffold, our processes are roughly these:

We select arbitrarily a small part of the universe for intensive study; we observe our piece of creation operationally and record our data in terms of a number of operationally derived concepts; we attempt to correlate the variations in these concepts; we guess at a mechanism for the system which contains postulated concepts similar to our operationally derived concepts and other postulated concepts leading through theoretical processes to concepts similar to our derived concepts; from the postulated mechanism we deduce logically the behavior of the system; we compare the predicted behavior of the postulated system with the observed behavior of the real system insofar as our abilities permit the observation.

Our "discovery," if any, is a guess. It gains physical reality in our minds only when the processes of deductive logic lead from our guess to physically verifiable observations on a consistent basis and over a fairly wide range of experience

On the geometrical model, the above process consists of a selection of a small region in the multi-dimensional space, the consideration of a cross section of this region in which all but a few coordinates are held constant, and the probing of the section to determine at what points the representative point may lie. When we have made a number of such probings we guess at a mechanism which would exhibit similar behavior. From this mechanism we then calculate the shape of the multi-dimensional surface or the probability density of points in our selected region and we probe further to determine whether the distribution computed from our guess lies within the limits of experimental error close to the physically observed distribution. When the same postulated concepts lead to fairly accurate fits over a wide region of the surface we tend to ascribe physical reality to the concepts so postulated. When a number of different postulated concepts lead to distributions which represent nature equally well over the same range, there is no basis for choice among them and we must accord each the same measure of reality. We generally accept those which cover the widest variety of fields with the least complication.

If we can adequately picture the universe in terms of a multi-dimensional surface or probability distribution, then physics will converge only when the entire surface (which may be infinite) has been covered, and when our postulated multi-dimensional surface or probability function approaches the real one to a distance less than the proverbial epsilon; i.e. when all experimental errors are

eliminated completely. In the past these small errors of observation have concealed high explosives, and there is no reason to think that they will not do so in the future. In the light of this reasoning, the eventual reduction of all physical constants to four or to twenty, while highly desirable, seems difficult to conceive.

RICHARD C. RAYMOND
Pennsylvania State College
State College, Pennsylvania

Triple Trouble

Sir:

On page 8 of your December issue of Physics Today is a picture captioned "Max Planck," and in the text he is referred to as Max Karl Planck. This is quite a mixup. You have, in the text, joined the father and the oldest son in one person, and in the picture confused the father with a second son, Erwin.

Max Planck, discoverer of the quantum theory, was born on April 23, 1858. Karl Planck, his oldest son, was born on September 3, 1888, and was killed in the first World War. Erwin Planck, the second son, was born on December 3, 1893 and executed by Hitler in March, 1945. The picture on page 8 is of Erwin Planck, according to friends of the family.

ING. BRUCHE
Physikalische Blätter
Mosbach (Baden), Germany

The transmutation involved could not have been more complicated, more wrong, more embarrassing, or made in more good faith. To set matters right we print below a cut of Max Planck, the father, and originator of the quantum theory.

MAX PLANCK

Keystone