# Letters to the Editor

*PROMPT publication of brief reports of important discoveries in physics may be secured by addressing them to this department. The closing date for this department is the third of the month. Because of the late closing date for the section no proof can be shown to authors. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents. Communications should not in general exceed 600 words in length.*

## Order in the Alloy $Cu_3Au$[1]

L. H. GERMER, F. E. HAWORTH, AND J. J. LANDER
*Bell Telephone Laboratories, New York, New York*
December 5, 1941

FILMS of the copper-gold alloy of the composition corresponding to $Cu_3Au$ have been investigated by electron diffraction by the transmission method. The specimens, which are about 400A thick,[2] have in some cases been prepared for examination by heating for long periods of time in an evacuated container, the treatment ending either with slow cooling or with rapid quenching from a high temperature. Other films have been heated in a high temperature furnace located within the diffraction camera, and electron-scattering patterns have been obtained from these films at various elevated temperatures.

Order, as evidenced by the appearance in the electron patterns of rings having mixed indices, is produced by heating for 16 hours at 170°C, but from diffuseness of these rings we estimate that there are anti-phase domains in the alloy crystals; patterns from films which have been heated only at 160°C do not exhibit these superstructure rings. These observations are a direct confirmation of the indirect conclusion of Nix and MacNair[3] from dilatometer measurements that the copper-gold alloy containing twenty-five atomic percent gold begins to order at a temperature somewhat below 200°C.

Stronger and sharper superstructure rings are obtained from films which have been heated at higher temperatures, and in Fig. 1 is reproduced a pattern corresponding to a degree of order which we estimate to be perfect.

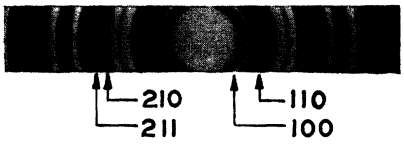


FIG. 1. Electron diffraction pattern from $Cu_3Au$ in completely ordered condition, with designation of the four smallest superstructure rings.

FIG. 2. Pattern from $Cu_3Au$ at 400°C showing unresolved (100) and (110) superstructure ring. Patterns which appear to be identical with this were obtained at temperatures from 370°C to 550°C.

Diffraction patterns from films which have been quenched from temperatures above 400°C are made up of sharp rings characteristic of face-centered cubic crystals of $Cu_3Au$ without superstructure; but in addition to the sharp rings there is a very broad, ill-defined band at about the location of the (100) ring of Fig. 1. (See the pattern of Fig. 2.) If this ring is an indication of slight order in the alloy, it must either have existed at the high temperature before quench or have developed in the very short interval of time (about one second) during which the film was cooled.

Tests for order above the Curie point (380° or 390°C) have been made by obtaining patterns from films at elevated temperatures. Many series of experiments have been carried out in which films have been heated, or cooled, in the diffraction camera at a rate of about 50° per hour with electron patterns taken at frequent intervals. When an ordered specimen is heated at this rate, diffraction patterns from it, as judged from their microphotometer curves, exhibit no marked change until about 300°C is reached. Above this temperature the superstructure rings become gradually broader and less prominent, and reach finally a steady condition at about 370°C. At this temperature and at higher temperatures up to 550°C, which is the limit of our observations, the diffraction pattern is like that of Fig. 2. From the microphotometer curves one discovers that what appears as a single broad inner band on Fig. 2 is made up of (100) and (110) rings in a practically unresolvable condition.

The existence of superstructure lines above the Curie point, as an indication of short-range order, has been explicitly predicted by Peierls and implicitly by Bethe[4] and others, but as far as we are aware these lines have not been observed heretofore. From the breadths and shapes of the rings one should be able to draw significant conclusions about the nature of order above the Curie point. To do this, however, it seems to us necessary to give detailed consideration to short-range order in crystals and to the diffraction effects which could be produced.

[1] Brief accounts of part of this work have been presented at meetings of the American Physical Society, Phys. Rev. **56**, 212 (1939); **57**, 354 (1940).
[2] For the method of preparation see references 1, and L. H. Germer, Phys. Rev. **56**, 58–71 (1939).
[3] F. C. Nix and D. MacNair, Phys. Rev. **60**, 302 (1941). See Fig. 7 for the alloy $Cu_3Au$. C. Sykes and F. W. Jones have concluded from specific heat data that ordering begins to occur in disordered $Cu_3Au$ at temperatures even below 100°C [Proc. Roy. Soc. **A157**, 213 (1936)].
[4] R. Peierls, Proc. Roy. Soc. **A154**, 207 (1936); H. A. Bethe, Proc. Roy. Soc. **A150**, 552 (1935).

## A New Induction Accelerator Generating 20 Mev

D. W. KERST*
*Research Laboratory, General Electric Company, Schenectady, New York*
December 17, 1941

FOLLOWING a design similar to that used for a 2.3-Mev induction accelerator[1] a larger accelerator with a 19-inch pole face has been constructed. The new accelerator has its equilibrium orbit at a radius of approximately 19 centimeters, and the electrons reach an energy of 20 Mev. Instead of saturation of the central flux causing

the electrons to spiral inward to a target when the magnetic field approaches its maximum value, the orbits are expanded outwardly so that the electrons impinge on the tungsten injector structure which serves as a target for the production of x-rays and for the scattering of the primary electrons. This expansion is produced by a pulse of flux generated by auxiliary coils which are arranged to supply flux through the center of the orbit. These auxiliary coils are energized abruptly after the main magnetic field has reached its peak value, and the additional momentum gained by the sudden increase of central flux moves the electron orbit to larger radii.

While in operation for several months at 13 million volts the accelerator output reached 4.3 r per minute at a distance of one meter from the target as measured by an ionization chamber with thick Bakelite walls. The x-ray output measured in the same way at 20 Mev is now 16 r per minute. The radiation proceeds forward in a small cone and produces a photographic effect mainly confined within a 6° angle.

It is possible to cause the electrons to strike the target at any desired energy below the maximum of 20 Mev by controlling the phase at which the auxiliary coils are energized or by controlling the amplitude of oscillation of the main magnetic field with the auxiliary coils timed to expand the orbit at the peak of the field. The energy which the electrons reach is determined at present by measurements of the peak magnetic field.

In order to cut down bombardment of the inside of the vacuum doughnut and to improve the yield of the accelerator, electrons are injected at 15 or 20 kilovolts for only a brief interval overlapping the time when the field goes through zero. Estimates of the amount of charge which the orbit can hold show that a time average current striking the target of as much as one microampere can be expected. It is not certain that the orbit is now being completely filled.

* On leave of absence from the University of Illinois.
[1] D. W. Kerst, Phys. Rev. **60**, 47–53 (1941).

## On the Function $H(m, a, x) = \exp(-ix)F(m+1-ia, 2m+2, 2ix)$

ARNOLD N. LOWAN AND WILLIAM HORENSTEIN
*Mathematical Tables Project, Work Projects Administration, New York, New York*
November 28, 1941

THE Mathematical Tables Project has carried out some exploratory work on the function $H(m, a, x) = \exp(-ix)F(m+1-ia, 2m+2, 2ix)$ and has computed a six-page table giving the values of $H(m, a, x)$ and of its first derivative with respect to $x$ for the following values of the parameters: $m=0, 1, 2, 3$; $a=0, 1, 2 \ldots 10$; and $x=0, 1, 2 \ldots 10$. The project will consider extending the scope of the present short table by subtabulating for the variable $x$ and for the parameter $a$ provided this undertaking is warranted by the needs of the physicists. Accordingly, the project would welcome suggestions from those who have occasion to make use of the function in question. The following facts may be of importance to the readers of *The Physical Review*.

The function $H(m, a, x)$ satisfies the differential equation

$$x\frac{d^2H}{dx^2}+(2m+2)\frac{dH}{dx}+(x-2a)H=0.$$

An integral representation for $H(m, a, x)$ has been obtained in addition to several recursion formulae connecting (a) $H(m, a, x)$, $H(m+1, a, x)$ and $H(m+2, a, x)$; (b) $H(m, a, x)$ and $H(m+1, a, x)$ with their corresponding first derivatives; (c) $d/dx[H(m, a, x)]$ with $H(m, a, x)$ and $H(m+1, a, x)$; (d) $d/dx[H(m, a, x)]$ with $H(m, a, x)$ and $H(m-1, a, x)$. For the case $a=0$ there exists a simple relation between $H(m, a, x)$ and $J_{m+\frac{1}{2}}(x)$. The recursion formulae were found of great value in checking the values which had been computed from their power series expansion. They could also serve to generate the higher derivatives required in any eventual subtabulation.

## The Velocity of Sound in Methyl Methacrylate Polymer

LOUIS R. WEBER AND FRANK P. GOEDER
*Department of Physics, Colorado State College, Fort Collins, Colorado*
December 18, 1941

IN the first report made by the authors,[1] the velocity of sound in methyl methacrylate polymer (Lucite) was determined directly by means of Kundt's tube and indirectly from elasticity measurements made by stretching several specimen rods. The rods which were 100 cm long and one cm diameter, were subjected to tensile forces from one to 20 kilograms. The velocity by the latter method was found to be at variance with that of the other methods which is to be expected.[2,3] Measurements were continued more recently,[4] with compressional forces from 500 to 4000 lb./in.$^2$ on specimens of various diameters and lengths. The velocity of sound through these specimens was determined from these values as shown below.

The velocity was further investigated for a number of the same rods with a modification of the electrostatic method,[5] in which resonant frequencies are excited by setting up a modulated potential of the order of 1600 volts. Iron and brass rods were excited under the same conditions and the velocity of sound through them computed to well within the experimental error. The fundamental as well as several harmonics were excited in each rod. The modification proved to be sensitive as well as selective to these frequencies. The present results indicate the velocity of sound to be as follows in methyl methyacrylate.

| | |
|---|---|
| I. Dynamic method | |
| (a) Electrostatic excitation | 2070 meters/sec. |
| (b) Kundt's tube | 2090 meters/sec. |
| II. Static method | |
| (a) From Young's modulus (500 to 4000 lb./in.) | 1600 meters/sec. |

The stress-strain relationships from which measurements II (a) were made, were linear showing practically instant recovery so far as our instruments indicated. The strain was measured simultaneously with an optical lever and a compression micrometer. Young's modulus computed from