cause energy in the higher frequencies is more rapidly attenuated than in the lower, a dynamically stable wave form which is a function of the attenuation results. Not much of a specific nature seems to be known regarding the effect upon progressive change in wave form, although the effect has received much attention in connection with shock waves, and with the characteristics of sound produced by electroacoustic apparatus such as loud-speakers and signaling apparatus.

The development of short time spark shadow photography[3] has recently made it possible to photograph progressive sound waves in air in the millimeter wave-length region.[4] An outstanding characteristic of such photographs is the change in wave form which, after appearing to be symmetrical near the source, becomes sharpened on one side and, so far as has been determined, remains so for all intensities that can be photographed. An important problem was therefore to determine the respective thresholds of intensity at which, by several methods, distortion of wave form could be detected.[5] It became immediately apparent that some thresholds lie at relatively low intensity and that it is difficult to photograph ultrasonic waves at intensities low enough to avoid such a distortion. The characteristic appearance of a spark shadow photograph of a system of plane waves taken with light made parallel by a corrected lens is shown in Fig. 1. The duration of the spark is less than 10^{-7} sec. This is for air at 27°C, the frequency being 405 kc/sec. The ultrasonic wave-length is thus about 0.857 mm, and the travel during illumination 0.035 mm. A trace of this negative, kindly made by the Naval Ordnance Laboratory with a Leeds and Northrup recording microphotometer, is shown in Fig. 2. It will be observed that the waves, leaving the source with approximately a symmetrical form, almost immediately change to a form having a steeper front, suggesting the initial stages of shock wave formation.

A partial confirmation of these effects is provided by viewing the spectra produced by the negative used as an optical grating in a spectrometer of small aperture. The portion of field comprising the first eleven wave-lengths shows only the central image and two first-order spectra, the midportion of the negative shows the first and second orders very clearly, the third order being faintly visible, while the remainder shows only first and second orders.

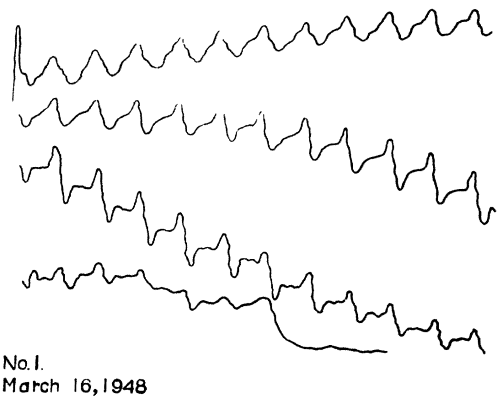

FIG. 2. Microphotometer trace of the negative of Fig. 1, starting from source, showing progressive change of symmetrical wave form into one with steeper fronts and increased harmonic content.

Spark shadow photographs of ultrasonic waves in water, glycerine, and carbon tetrachloride have also been made. below 75°C in water the phenomena are similar to those described in air, but the initial regime of symmetrical waves is very short. For normal liquids the temperature coefficient of sound velocity is negative and the order of events is reversed, the rear of the wave is steepened and the wave develops a saw tooth in reverse, or a sharp reduction in pressure is followed by a relatively long recovery. These and other examples of interest, both from the standpoint of difference of C_p and C_v, and that of temperature coefficient of velocity of sound, are being studied. The consequences of this behavior are especially significant for all types of ultrasonic measurement, and may well account for the many discrepancies in measured values of ultrasonic absorption, and to some extent as well for ultrasonic velocity. No doubt the characteristic emulsifying and other effects of intense sound or ultrasonic waves will be found to be closely connected with the effects described here. A more extended account of these experiments is being prepared.

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Velocity and Two-Directional Focusing of Charged Particles in Crossed Electric and Magnetic Fields

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FROM mass and β-spectroscopy two types of focusing devices are well known: the homogeneous magnetic field where focusing occurs after 180° and the electrical radial field with a focusing angle equal to $\pi/\sqrt{2}\sim 127°$. In the high precision mass spectrographs of Aston, Dempster, Bainbridge-Jordan, and Mattauch-Herzog, sector fields of both kinds are used in order to achieve both velocity and direction focusing. Another focusing principle, the two-directional focusing in an inhomogeneous magnetic field, proposed by K. Siegbahn and the present author,[1] has been applied in the construction of a new β-spectrometer in this Institute. The field strength decreases with increasing radius as follows.

$$H(r)=H_0[1+\alpha_1(r-r_0)/r_0+\alpha_2(r-r_0)^2/r_0^2+\cdots], \quad (1)$$

where $\alpha_1=-\frac{1}{2}$, $\alpha_2\sim\frac{3}{8}$, and $r_0=50$ cm.

In the present note it will be pointed out that if a magnetic field of the general shape (1) is combined with a

radial electric field of the form

$$E(r)=E_0[1+\beta_1(r-r_0)/r_0+\beta_2(r-r_0)^2/r_0^2+\cdots], \quad (2)$$

then radial and axial focusing occurs after the angles

$$\phi_r=\pi/[1+(\kappa-1)(\kappa-2)+\alpha_1\kappa+\beta_1(1-\kappa)]^{\frac{1}{2}} \quad (3)$$

and

$$\phi_z=\pi/[\kappa-1-\alpha_1\kappa-\beta_1(1-\kappa)]^{\frac{1}{2}}, \quad (4)$$

respectively. The quantity $\kappa=er_0H_0/mv_0$ is the ratio between the magnetic force and the centrifugal force. This result includes the following special cases: radial ($\phi_z=\infty$), axial ($\phi_r=\infty$), and two-directional ($\phi_r=\phi_z$) focusing in an electric field ($\kappa=0$), in a magnetic field ($\kappa=1$), and that special combination of an electric and a magnetic field where velocity focusing of the first order is achieved ($\kappa=2$). In this combination of fields an energy spread δE gives a resolving power proportional to $(E/\delta E)^2$ instead of $E/\delta E$ in all other cases. According to Eq. (4), the condition for radial focusing is $\beta_1=2\alpha_1-1$. For a homogeneous magnetic field ($\alpha_1=0$) and an electric cylinder field ($\beta_1=-1$) this focusing principle was proposed by Bartky and Dempster[2] and applied by Shaw[3] in the determination of e/m for electrons, and by Bondy and Popper[4] in a mass spectrometer with large primary energy spread. Two-directional focusing ($\phi_r=\phi_z=\pi$) occurs in the case $\kappa=2$ when $\beta_1=2\alpha_1$ and includes the following subcases.

(a) $\alpha_1=\beta_1=0$: a homogeneous magnetic field combined with a radial electrical field independent of r.

(b) $\alpha_1=-\frac{1}{2}$, $\beta_1=-1$: an electric cylinder field combined with a magnetic field of the type $1/(r)^{\frac{1}{2}}$.

(c) $\alpha_1=\frac{1}{4}$, $\beta_1=\frac{1}{2}$, and $\beta_2=2\alpha_2+\frac{1}{2}$: this special case gives, in addition to first-order velocity focusing, second-order focusing in radial as well as axial directions.

As an immediate consequence of these principles it should be possible to increase the resolving power of a Bleakney or Nier spectrometer by introducing two deflectors of approximately parabolic profile according to the case (a) above. It remains to be seen whether there is any possibility of applying these principles to a high precision instrument. There are, in principle, some definite advantages but possibly also some practical disadvantages. A detailed discussion will be given at a later occasion.

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On γ-Induced β-Disintegration: Experimental*

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An endoergic β-decay, induced by γ-radiation, will be energetically possible if the energy of the incident photons is greater than the sum of the rest energy of a positron-electron pair (1.02 Mev) and the mass difference between the initial and final atoms (assuming neutrinos of zero rest mass). Thus the product of an element of atomic number Z and mass number A which decays by the reaction

$$(Z)^A\rightarrow(Z+1)^A+e^-+\nu+Q$$

might undergo a reaction

$$(Z+1)^A+\gamma\rightarrow(Z)^A+e^++\nu,$$

(ν standing for a neutrino). In view of the probable radioactivity of the neutron,[1] the particular case $Z=0$ corresponds to the photo-disintegration of the proton. In spite of the small cross section predicted for such a process,[2] it was thought worth while to verify experimentally that the cross section was small compared to that for the production of photo-neutrons in deuterium and beryllium, by comparing the neutron yield in the three cases.

The thresholds for the photo-disintegration of the proton, deuteron,[3] and beryllium[5] are 1.77, 2.19, and 1.63 Mev, respectively. The first figure is the neutron-hydrogen mass difference of 0.75 Mev[3], plus the rest mass of a pair, 1.02 Mev. Cl^{38}, having a γ-ray capable of disintegrating H and Be but not D, would be a good source for the purpose, but was not available in sufficient strength; so Mn^{56}, with γ-rays at 0.845, 1.81, 2.13, and 2.7 Mev[4,5], was used. Two of these γ-rays could presumably produce photo-neutrons from either H or Be but not from D, while the last could produce them from all three.

A Mn^{56} source having a γ-ray strength of the order of $\frac{1}{3}$ rhm was surrounded by sufficient Lucite to reduce the energy of the fastest β-particles to below 2 Mev, and was placed at the center of a cylindrical vessel containing 22.5 liters of distilled water. Neutrons were detected by means of a silver cylinder which was placed between the γ-ray source and the water for three minutes, and then quickly transferred to a position in which it surrounded a thin-walled glass Geiger-Mueller counter.

Adding the counts obtained in three 30-second counting periods (each following a three-minute exposure) in each case, the counts, corrected for a background of 27 ± 2 counts, for activity remaining in the silver from previous runs, and for decay of the γ-ray source, were: with 1250 moles of distilled water, 7 ± 6; after replacing 25 g of the water by D_2O and stirring, 51 ± 9; and after replacing 750 cc of that water by an acid solution of the beryllium chloride containing $6\frac{1}{4}$ moles of Be, 552 ± 23. Using the second of these counts to correct the first and third for photo-neutrons attributable to the deuterium present, taking into account the numbers of atoms present in the same volume in the three cases, and assuming that an increase equal to one-third of the background count would have been observable in the case of hydrogen, the ratio of photo-neutron production per atom in H to that in Be must be less than 5×10^{-5}, while the ratio for Be to D is 5.

The latter ratio gives no information relative to cross sections, since the number of photons with energy sufficient to disintegrate D is smaller than the number able to disintegrate Be; it may be compared with the value of 7.7 for the same ratio, obtained by Russell *et al.*[6] (the ratio of their neutron yields per Curie-second has been multiplied by the ratio of the number of atoms of D to the number of atoms of Be used). Considering differences in