The sensitivity of the phase to stress was calculated directly by measuring the changes in position δx of the turning points when the compression was changed. It is straightforward to show that, if the change in compressional force is ΔT, then

$$\frac{\partial \ln \phi}{\partial \sigma} = \frac{a\,\delta x/B}{b\Delta T} \tag{2}$$

where a is a calibration factor which converts changes of position δx into equivalent changes of B and b is a factor (depending on the cross sectional area of the specimen) which converts changes of T into changes of σ. Equations (1) and (2) were used to find the stress sensitivity of the Fermi surface from measurements of δx. Generally δx and B were taken to be the mean values over a field sweep since this introduced no significant error. However, it was necessary to be more careful for the needles in zinc since B varied by a large fraction from turning point to turning point. In this case $\delta x/B$ was evaluated at each turning point and the average of this quotient taken afterwards.

Errors in our experimental results arose primarily from determining δx, though some error from the measurement of B as well as from a and b are included in the results.

The errors in B, a and b were routine; however it is worth discussing certain precautions taken in connection with the above procedure to ensure that spurious phase changes ($\propto \delta x$) were not being produced by the recording system. The most likely source of trouble would have been that the field–current relation of the magnet was irreproducible. We were able to check on this by doing a number of preliminary field sweeps at fixed T to check on the reproducibility of the phases of the oscillations as plotted. It was never possible to obtain reproducible results when comparing up and down sweeps. However, it was always possible to get more or less identical up (or down) sweeps provided that the range of B swept was kept approximately constant. In fact a reason for always returning to a final T_0 sweep at the end of a series was to check that the phases were unchanged from the initial T_0 sweep.

Another potential source of recording error was the possibility of long term drift in the back off on the X displacement of the X–Y recorder. Again, the plotting of the final T_0 plots would have shown up any steady drift of this kind. Shorter term fluctuations capable of producing a shift of the curves to left or right were also monitored by ensuring that on each sweep a given field current (determined by a high sensitivity digital voltmeter) always corresponded to a fixed X displacement. Occasionally slight long term drift was observed but this was measured and allowed for in measurements of δx.

Random errors, produced by the difficulty of estimating the maxima and minima of the curves, were calculated by measuring and comparing all the turning points (except those near the ends) and it was found that these random errors were always appreciably larger than any likely systematic errors in the detection system.

Nevertheless, consistency experiments on a single specimen could not rule out the possibility that the specimen was systematically rotating, for example, when compression was applied to it. We therefore used two or more specimens and compared results from different specimens. Since the differences between specimens were not significant in comparison with the random errors, there is no reason for believing that errors due to rotation or translation of the specimens were important.

Another potential error arising from the mechanical system was that on the first application of stress there was sometimes some amplitude reduction accompanied by an irreversible change of phase, due, presumably, to plastic effects. This source of error was automatically checked by the procedure of always returning at the end of a sequence to T_0 and checking the phase. However, a preliminary application and removal of stress was always made as this seemed to ensure elastic behaviour thereafter.

It is worth comparing the phase observation technique of Shoenberg and Watts (1967) in which they obtained very high field stability by using their magnet in the persistent mode. For the most part they were studying high de Haas–van Alphen frequencies. Since these have a very small field interval between oscillations, a high field stability was required but only a small field sweep was necessary to display the oscillations. Therefore their persistent mode technique is ideal, because the limitation that it has too small field sweeps does not matter. However, for lower frequencies such as we have studied the field stability criterion is proportionately lower, whereas the need for a larger sweep range is proportionately greater. Therefore, in our experiments we adopted the different procedure described above.

We were able to observe several de Haas–van Alphen frequencies with $\boldsymbol{B}$ along $\langle 0001 \rangle$ but in order to measure phase changes of the weaker ones it was necessary to filter out the ones of higher amplitude. We did this generally by using a variable low frequency electronic filter in the output of the detection system. This filter was adjusted to accept the frequency of interest. In two cases (the α and β oscillations in both zinc and cadmium to be described) where two close frequencies produced beats (figure 3) we determined the phase change of the dominant oscillation directly and inferred the other by measuring the shift in the beat pattern.

3. Results

3.1. General

Our experimental apparatus restricted our studies to extremal orbits lying in $\{0001\}$ planes through the Fermi surfaces. The compressional stress along $\langle 0001 \rangle$ retains the hexagonal symmetry of the Brillouin zone but increases its volume and its height (along $\langle 0001 \rangle$) and reduces its width.

The Fermi surfaces and the observed orbits in zinc and cadmium are discussed by Fletcher *et al* (1969) with references to other work.

We shall tabulate our results in three alternative forms. The most straightforward form $\partial \ln \partial\sigma$, is obtained directly from the experiment.

The second form is the ratio of the measured fractional area change to the theoretical fractional change for a free electron sphere of cross sectional area A_s

$$\frac{\partial \ln A_s}{\partial \sigma} = \frac{2}{3}\frac{\partial \ln V}{\partial \sigma}$$

where V is the volume of the Brillouin zone. We used the appropriate low temperature elastic constants to calculate the dimensionless quantity $\partial \ln A/\partial \ln A_s$ which would take values close to $+1$ for orbits which are like those on the free electron sphere. It is worth noticing how our results, which are from small orbits, differ from $+1$ in both magnitude and sometimes sign.

The third form is used to make an objective comparison of our results with other work on the sensitivity of the orbits to hydrostatic pressure and thermal expansion. We observe that uniaxial compression produces a change in the axial ratio c/a. However, because of the large anisotropy of the elastic constants, hydrostatic pressure and thermal expansion also produce changes in the c/a ratio. Therefore, we can express all three kinds of experiments in a common way, in terms of $\partial \ln A/\partial(c/a)$.