n-type InSb. Secondly, the valence band maxima are probably very similar to that for Ge and Si; at least, any model which will describe the elastoresistivity of extrinsic p-type Ge and Si could undoubtedly be applied to p-type InSb. In addition, it does not seem unreasonable that the valence band picture described by Kane would also result in shear-type elastoresistance coefficients like those observed.

The large variation observed for the volume effect $\delta \ln\rho/\delta \ln V$ indicates the effect of lattice dilatation on the forbidden energy gap. By considering that the product np changes with strain only as E_g varies, the deformation potential E_{1g} was determined to be very nearly -7.0 ev which corresponds to the value determined by Ehrenreich[20] from the pressure dependence of the Hall constant given by Long.[7]

VI. ACKNOWLEDGMENTS

It is a pleasure to acknowledge the able assistance in instrumentation given by W. J. McKean. D. E. Roberts provided the single crystals of InSb from which the samples were prepared and W. R. Hosler measured the Hall and conductivity data of Table I. I wish to thank A. J. Tuzzolino for transmitting to me some of his results before publication.

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Soft X-Ray Absorption by Thin Films of Vanadium*

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The absorption of soft x-rays by vanadium has been measured in the spectral region between 190 A and 250 A. The observed absorption band is interpreted as a combination of M_3 and M_2 bands in the ratio of 2:1 and separated by 1.5 ev. The results are compared with previous determinations on chromium and iron.

The M_{23} absorption bands of vanadium have been measured. This absorption is produced by transitions from the $3P_{\frac{3}{2},\frac{1}{2}}$ states to the unfilled portion of the conduction band. The apparatus and experimental procedure are essentially the same as described previously[1] and will not be discussed here.

Films were prepared by vacuum evaporation onto thin celluloid supports from two parallel tungsten wires 0.050 inch in diameter. The vanadium was vacuum-fused at a pressure of 2×10^{-5} mm Hg. During evaporation the pressure was kept below 10^{-4} mm Hg and the evaporator was kept cool by intermittent evaporation. Currents of approximately 12 amp were used for 15-second intervals, between which the system was allowed to pump down to the original vacuum. In this way films of the required thickness were built up.

The films ranged in thickness from 25 A to 300 A. Absorption was determined by comparing the transmission of two films of different thicknesses but which were otherwise identical in preparation. The difference of thickness between the two films used for any one run was kept between 130 A and 140 A.

Film thicknesses were determined by measuring the optical density in visible light, the optical density *vs* thickness curve having been previously determined by using fringes of equal chromatic order.[2] The vanadium was obtained from Jarrell-Ash Company containing as chief impurities 0.04% iron, 0.044% carbon, and 0.085% oxygen.

Results of the absorption measurements are shown in Fig. 1. The solid curve represents the average of three independent runs, two runs on one set of samples and one on another set prepared in a separate evapo-

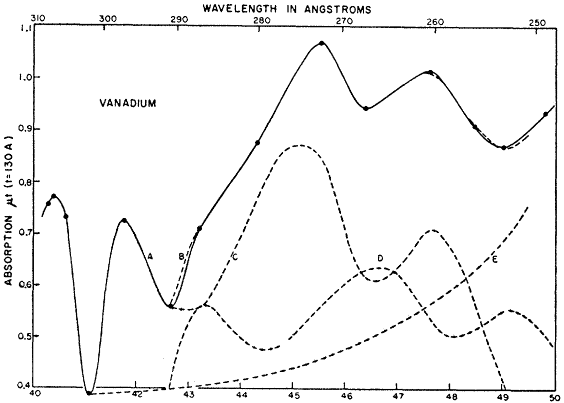

FIG. 1. The soft x-ray absorption band of vanadium and its components. A—experimental curve; B—sum of curves C, D, and E; C and D—suggested M_3 and M_2 bands; E—background.

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ration. Also shown in Fig. 1 is a suggested separation of the band into two parts representing the absorption due to M_3 and M_2 separately. The separation was made on the assumption that the two curves would have the same shape. Their relative intensities and their separation were adjusted to obtain a fit. The curves shown, which represent a good fit, are in the ratio of 2:1 and have a separation of 1.5 ev between the two bands.

Since the M_{23} states are *p*-type states, the individual curves should represent the combined densities of *s*- and *d*-type states in the unfilled portion of the conduction band. The conduction band in solid vanadium is derived from the 4*s* and 3*d* atomic states. In the solid *d*-type wave functions are expected to be prominent since the 3*d* state can accommodate five times as many electrons as the 4*s* state. In vanadium the 3*d* band is expected to be less than half full. This may perhaps explain the presence of an extra peak on the low-energy side of the resolved band.

Since both the ratio and the separation of the bands may be adjusted (and to a lesser extent the background also may be adjusted), the separation of the band into its two components is not necessarily unique. We tried ratios of 3:2 and 1:1 but were unable to make a fit using any value of the separation. It is possible that some other ratio might be found which would give another satisfactory decomposition. The ratio 2:1 is also attractive because this is the predicted ratio for atomic vanadium. The separation of the M_{23} levels of atomic vanadium is predicted[3] as 0.8 ev.

TABLE I. Comparison of the soft x-ray data on iron, chromium, and vanadium.

		Emission		Absorption present work	Total width emission + absorption
		Gyorgy and Harvey	Skinner *et al.*		
Fe	M_2-M_3 separation	0.6 ev	1.4 ev	1.6 ev	
	M_3 width	3.7 ev	5.0 ev	9.8 ev	5.0+9.8 =14.8 ev
	M_3/M_2	1/2	2/1	2/1	
Cr	M_2-M_3 separation	0.45 ev	1.0 ev	1.5 ev	
	M_3 width	7.2 ev	7.2 ev	7.5 ev	7.2+7.5 =14.7 ev
	M_3/M_2	1/2	2/1	3/2	
V	M_2-M_3 separation	...	0.9 ev	1.5 ev	
	M_3 width	...	7.0 ev	8.0 ev	7.0+8.0 =15.0 ev
	M_3/M_2	...	2/1	2/1	

The metals vanadium, chromium, and iron (with atomic numbers 23, 24, and 26, respectively) have body-centered cubic crystalline form. The theoretical work of Slater and Koster[4] is therefore applicable to the 3*d* band of these metals. Also the lattice constant is nearly the same for these metals (3.03 A, 2.88 A, and 2.86 A), and so it is interesting to observe that the total width of the 3*d* band is the same in these three metals. Neglecting the comparatively small contribution by the 4*s* band, the 3*d* band may be experimentally determined as the sum of the widths of the M_3 emission and absorption bands. Table I summarizes this comparison. The figures on emission were taken from Gyorgy and Harvey[5] and also from Skinner *et al.*[6] The absorption figures on iron and chromium are from work previously reported by the authors.[1,7] The table also summarizes some of the pertinent features of the emission and absorption spectra of these metals.

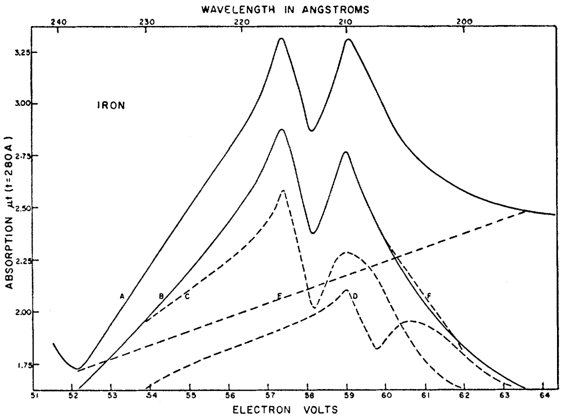

FIG. 2. The soft x-ray absorption band of iron and its components. A—experimental curve; B—experimental curve minus the background; C and D—suggested M_3 and M_2 bands; E—background; F—sum of curves C and D.

In order to make this comparison, the iron data previously reported[7] have been resolved into two components, the M_3 and M_2 bands having the intensity ratio 2:1 and separation 1.6 ev. The method used was the same as has been described for vanadium. The results of this decomposition are shown in Fig. 2.

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