

TABLE I. Summary of shock-wave compression measurements on 30% and 36% Ni-Fe alloys.

n^a (mm/ μ sec)	Specimen thickness (mm)	n^b (mm/ μ sec)	σ^c (kbar)	30% Ni-70% Fe fcc				
				U^d (mm/ μ sec)	σ^e (kbar)	$(V/V_0)^f$	σ^g (kbar)	n^h (mm/ μ sec)
0.2709	12.81	0.1355	...	5.06	4.6	0.9978	45.4	0.9688
0.3737	9.538	...	38.5	5.05	4.2	0.9980	40.2	0.9719
0.3247	9.538	...	34.4	5.14	4.1	0.9980	34.4	0.9752
0.2921	9.525	...	30.0	4.99	3.9	0.9981	29.0	0.9784
0.2483	9.525	...	25.8	4.97	2.9	0.9986	25.0	0.9806
0.2324	9.525	...	24.0	4.98	2.9	0.9982	23.5	0.9823
0.1234	12.81	0.0617	...	5.02-5.00	4.7	0.9977	20.7 ^k	0.9847
0.0902	12.81	0.0451	...	...	4.4	0.9980	15.9	0.9884
0.1380	...	0.0396 ^l	14.9 ^l	...	...	...	...	0.9914 ^l
Mean density 8.158 g/cm ³ ; $C_0=5.01$ mm/ μ sec; $\sigma^c=2.92$ mm/ μ sec; $U^d=4.37$ kbar; $U^e=5.027$ mm/ μ sec								
0.2735	12.79	0.1368	...	5.14	...	...	49.8	0.9708
0.1126	12.79	0.0563	...	...	...	...	21.8	0.9876
0.0922	12.79	0.0461	...	5.11	...	...	17.9	0.9900
Mean density 8.032 g/cm ³ ; $C_0=5.23$ mm/ μ sec; $U^d=5.13$ mm/ μ sec								
0.2853	12.72	0.1427	...	4.91	4.3	0.9977	44.2	0.9646
0.1878	12.74	0.0939	...	4.84	5.3	0.9972	30.8	0.9752
0.1090	12.74	0.0545	...	...	5.3	0.9972	18.2	0.9865
Mean density 8.077 g/cm ³ ; $C_0=4.73$ mm/ μ sec; $\sigma^c=5.0$ kbar; $U^d=4.88$ mm/ μ sec								

^a Measured impact velocity.^b Particle velocity imparted to the specimen for symmetrical impacts.^c Stress imparted to the specimen as measured by a quartz gage.^d Wave velocity of elastic wave.^e Hugoniot elastic limit.^f Relative volume at Hugoniot elastic limit.^g Maximum stress of plastic wave.^h Computed relative volume of plastic wave.ⁱ Maximum particle velocity of second plastic wave.^j Final stress value was not recorded due to partial experimental failure.^k The value shown was adjusted to agree with the input value.^l Impact surface experiment only. The initial temperature of the sample was 130°C.^m Low signal dilatational velocity as obtained by ultrasonic pulsing.ⁿ Low signal shear-wave velocity as obtained by ultrasonic pulsing.^o Maximum stress of plastic wave.^p Computed relative volume of plastic wave.^q Relative volume at Hugoniot elastic limit.^r Hugoniot elastic limit.^s Stress imparted to the specimen as measured by a quartz gage.^t Wave velocity of elastic wave.^u Relative volume at Hugoniot elastic limit.^v Maximum stress of plastic wave.^w Computed relative volume of plastic wave.^x Relative volume at Hugoniot elastic limit.^y Hugoniot elastic limit.^z Stress imparted to the specimen as measured by a quartz gage.^{aa} Wave velocity of elastic wave.^{ab} Relative volume at Hugoniot elastic limit.^{ac} Hugoniot elastic limit.^{ad} Stress imparted to the specimen as measured by a quartz gage.^{ae} Wave velocity of elastic wave.^{af} Relative volume at Hugoniot elastic limit.^{ag} Hugoniot elastic limit.^{ah} Stress 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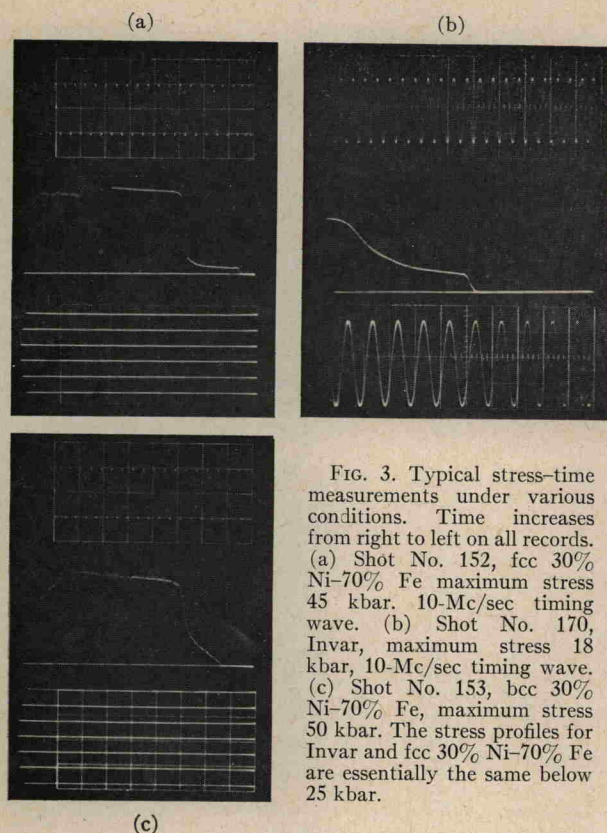


FIG. 3. Typical stress-time measurements under various conditions. Time increases from right to left on all records. (a) Shot No. 152, fcc 30% Ni-70% Fe maximum stress 45 kbar, 10-Mc/sec timing wave. (b) Shot No. 170, Invar, maximum stress 18 kbar, 10-Mc/sec timing wave. (c) Shot No. 153, bcc 30% Ni-70% Fe, maximum stress 50 kbar. The stress profiles for Invar and fcc 30% Ni-70% Fe are essentially the same below 25 kbar.

X-ray examination of the heat-treated samples showed that to the limit of detectability (5%) no minority phase was present. To determine atmospheric pressure elastic constants, typical samples were pulsed ultrasonically with results as shown in Table I. Chemical analyses were obtained on the samples which, for a given alloy, were all cut from the same bar of material. The mean value for the nickel content was 29.53% with a variance of 0.24%.

Since it was desired to measure the change in Curie temperature with pressure, it was necessary to measure the atmospheric-pressure Curie temperature for the 30% Ni-Fe alloy. This was determined by dilatometer measurements on bulk samples and x-ray lattice spacing vs temperature measurements. The value obtained for the Curie temperature from the thermal expansion measurements was $155^{\circ} \pm 3^{\circ}\text{C}$.

RESULTS

Typical stress-time profiles for various materials and various stress regions are shown in Fig. 3. The leading part of the profile results from the transition from elastic to plastic deformation. The sharp rise in stress for the second wave in Fig. 3(a) and the faster arrival time compared with that in Fig. 3(b) is that expected if the input stress is above the transition. Whereas, the slower rise in Fig. 3(b) is that expected if the stress input to the sample is below the transition.

The profile in Fig. 3(c) for the bcc alloy was obtained for an input particle velocity approximately equal to that in Fig. 3(a) for the fcc alloy. The bcc alloy shows a poorly defined precursor region, but, in any event, much faster arrival times are observed for all stress amplitudes as is indicative of lower compressibility.

The excellent time-resolution of the quartz gauge has revealed that few materials give idealized step function stress-time profiles. Hence, to reduce the stress-time profiles to stress-volume points the profile observed must be approximated by a series of small incremental steps constructed around the observed profile. This procedure has the further advantage that corrections can be made for the slightly variable response of the gauge. The solution for the incident stress from the measured interface stress was accomplished for each small increment of stress using the linear mismatch relations and the appropriate shock velocity for each step. The resulting final values can be checked against the measured input conditions to the sample as an over-all check of experimental errors and errors in data reduction. The data obtained on all experiments are tabulated in Table I. Most of the experiments were performed on fcc 30% Ni with less extensive experiments on 36% Ni and bcc 30% Ni.

The resulting stress-volume relations for the 30% Ni alloys are shown in Fig. 4. The cusp in the fcc curve at 4.3 kbar is the mean value observed for the Hugoniot

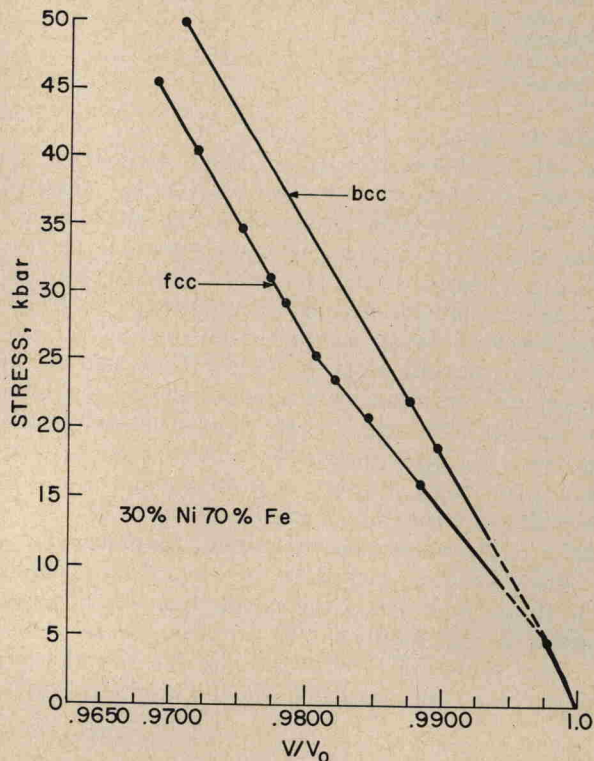


FIG. 4. Stress-volume relation for 30% Ni-70% Fe in the fcc and bcc phases.