

MIL-T-1368C  
2 June 1965  
SUPERSEDING  
MIL-T-1368B  
18 March 1958

## MILITARY SPECIFICATION

### TUBE AND PIPE, NICKEL-COPPER ALLOY, SEAMLESS AND WELDED

This specification is mandatory for use by all Departments and Agencies of the Department of Defense.

#### 1. SCOPE

1.1 Scope. This specification covers tube and pipe for use where the strength and corrosion resistance of nickel-copper alloy (Monel) are required.

1.2 Classification. Tube and pipe covered by this specification shall be of the following classes, as specified (see 6.2):

Class A - Seamless, Cold Drawn, Annealed.

Class B - Seamless, Cold Drawn, Stress Relieved.

Class C - Welded, Annealed.

Class D - Welded, Stress Relieved.

1.3 Pipe. Sizes of cold-drawn, seamless, nickel-copper-alloy pipe commercially available shown in 6.5 are for information only. When other schedules or wall thicknesses are required the manufacturer should be consulted.

#### 2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal form a part of this specification to the extent specified herein.

#### SPECIFICATION

##### Military

MIL-C-3993 - Copper and Copper-Base Alloy Mill Products Packaging of

FSC 4710

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STANDARDS

Federal

Federal Test Method Standard No. 151 - Metals; Test Methods  
FED-STD-182 - Continuous Identification Marking of Nickel and  
Nickel Base Alloys

Military

MIL-STD-105 - Sampling Procedures and Tables for Inspection by  
Attributes  
MIL-STD-129 - Marking for Shipment and Storage

(Copies of specifications and standards required by suppliers in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

American Society for Testing and Materials (ASTM)

E190-64 - Guided Bend Test, for Ductility of Welds

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.)

Official Classification Committee

Uniform Freight Classification Rules

(Application for copies should be addressed to the Official Classification Committee, 1 Park Avenue at 33rd Street, New York, N.Y. 10016.)

3. REQUIREMENTS

3.1 Material. The material used in the fabrication of the tube and pipe shall be such as to produce items that are in full conformance with chemical and physical requirements of this specification.

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3.2 Chemical requirements. All tube and pipe shall conform to the chemical requirements of table I.

Table I. Composition

Element	Percent
Nickel <sup>1</sup>	63.0 - 70.0
Iron	2.50 max.
Aluminum	.50 max.
Manganese	1.25 max.
Carbon	.20 max.
Silicon	.50 max.
Sulphur	.015 max.
Lead <sup>2</sup>	.006 max.
Phosphorus <sup>2</sup>	.02 max.
Tin <sup>2</sup>	.006 max.
Zinc <sup>2</sup>	.02 max.
Copper	Remainder

<sup>1</sup>Cobalt counting as Nickel.

<sup>2</sup>These elements need not be determined or reported by the vendor. However, if determined by the purchaser or contractor, the values will not exceed those shown.

3.3 Mechanical properties. All tube and pipe shall conform to the mechanical properties shown in the following table II:

Table II. Mechanical Properties

Condition	Tensile Strength	Yield Strength at 0.2 Percent Offset or at Extension Indicated (Min.)		Elongation in 2 in. (Minimum)
	Per Square Inch (Min.)	Per Square Inch	Under Load in 2 Inches	Percent
Classes A and C Annealed 5 inch and smaller outside diameter	70,000	28,000	0.0062	35
Over 5 inch outside diameter	70,000	25,000	0.0059	35
Classes B and D Stress relieved All sizes	85,000	55,000	0.0082	15

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## 3.4 Physical properties.

3.4.1 Tensile strength. Tube or pipe, when tested in accordance with 4.3.3 and 4.5.1, shall meet the applicable mechanical properties in table II.

3.4.2 Flattening (Class A only). Tube or pipe of class A, having an outside diameter at least 3 inches, shall show no injurious defects on any surface after flattening and opening of the flattened section as specified in 4.5.2.

3.4.3 Bending (Class C only). Class C tube or pipe shall show no cracks or openings when bent as specified in 4.5.3.

3.4.4 Flaring (Class A and Class C only). Class A and class C tube or pipe, having an outside diameter of 3 inches or less, shall show no evidence of fracture when tested as specified in 4.5.4.

3.4.5 Hydrostatic test pressure. Each tube or pipe shall withstand an internal hydrostatic test of 1,000 pounds per square inch (p.s.i.) without weepage, leakage, or drop in gage pressure, provided that the fibre stress calculated by the following formula does not exceed the allowable fibre stress S indicated below:

$$P = \frac{2ST}{D}$$

where P = Hydrostatic test pressure, p.s.i.

S = Allowable fibre stress for material in the condition furnished, as follows:

<u>Class</u>	<u>Allowable fibre stress-S</u>
A & C - Annealed: 5 inch outside diameter and smaller	17,500
over 5 inch outside diameter	16,700
B & D - Stress Relieved	21,250

T = Minimum wall thickness in inches; equal to the specified "average" wall minus the permissible "minus" wall tolerance, shown in table III, or the specified minimum wall thickness.

D = Outside diameter of tube or pipe in inches.

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Table III. Permissible variations - outside and inside diameter and wall thickness (average wall).

Specified Outside Diameter or Calculated Nominal Outside Diameter, inch. (When Ordered to Inside Diameter and Average Wall)	Permissible Variations			
	Outside Dia. <sup>a</sup> or Inside Dia. a,b		Wall Thickness, c,e,f	
	inch		percent	
	Plus	Minus	Plus	Minus
.400 and under	0.004	0	10	10
Over 0.400 to 5/8, excl.	0.005	0 <sup>d</sup>	12.5	12.5
5/8 to 1-1/2, incl.	0.005	0.005	10	10
Over 1-1/2 to 4-1/2, incl.	0.010	0.010	10	10
Over 4-1/2 to 6, incl.	0.015	0.015	12.5	12.5
Over 6 to 7-1/2, incl.	0.020	0.020	12.5	12.5
Over 7-1/2 to 8-5/8, incl.	0.025	0.025	12.5	12.5

<sup>a</sup>The permissible variations in the above table apply to individual measurements, including out-of-roundness (ovality), except for the following conditions:

Thin-Wall Tube and Pipe. For thin-wall tube and pipe having a nominal wall thickness of 3 percent or less of the nominal outside diameter, in all conditions (temper), the mean outside diameter or mean inside diameter shall conform to the permissible variations of the above table and individual measurements (including ovality) shall conform to the plus and minus values of the table, with the values increased by 0.5 percent of the nominal outside diameter.

Annealed Tube and Pipe over 4-1/2 inch in Nominal Outside Diameter. For annealed tube and pipe over 4-1/2 inches in nominal outside diameter with a nominal wall thickness greater than 3 percent of the nominal outside diameter, the mean outside diameter or mean inside diameter shall conform to the permissible variations of the above table and individual measurements shall not exceed twice the permissible variations of the above table.

<sup>b</sup>For tube and pipe, in all tempers, with an inside diameter of less than 1/2 inch which cannot be successfully drawn over a mandrel, the inside diameter shall be governed by the outside diameter and the wall thickness variations.

<sup>c</sup>For tube and pipe in all tempers with an inside diameter less than 50 percent of the outside diameter, which cannot be successfully drawn over a mandrel, the inside diameter may vary over or under by an amount equal to 10 percent of the nominal wall thickness and the wall thickness may vary plus or minus 12.5 percent.

<sup>d</sup>When inside diameter is specified, tubes with an inside diameter of 1/2 inch or over and with an outside diameter of under 5/8 inch shall have a permissible variation in inside diameter of plus and minus 0.005 inch.

<sup>e</sup>Eccentricity. The variation in wall thickness in any one cross section of any one tube or pipe shall not exceed plus or minus 10 percent of the actual (measured) average wall of that section (defined as the average of the thickest and the thinnest wall in that section).

<sup>f</sup>When minimum wall tube or pipe is required, the wall tolerance will be the total of the plus and minus wall tolerance from the table all applied to the plus side, e.g., in the case of an O.D. .400 and under the wall tolerance would be plus 20 percent minus 0.

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3.5 Permissible variations (Tolerances). Permissible variations in outside diameter and wall thickness shall be as shown in table III.

3.5.1 Tubing for silver brazing. When tubing for silver brazing is specified, tubing O.D. variations shall be negative (plus 0) with the permissible minus variations (tolerance) equal to the total O.D. range as shown in table III.

3.5.2 Length tolerance. When tube or pipe is ordered cut-to-length, the length shall not be less than that specified, but a variation of plus 1/8 inch will be permitted for lengths up to 30 feet, inclusive. For lengths over 30 feet, a variation of plus 1/4 inch will be permitted.

3.5.3 Random lengths. When ordered to random lengths, tube and pipe may be furnished in lengths from 5 to 24 feet, providing not more than 25 percent by weight is furnished in lengths from 5 to 10 feet. In the case of tubes with wall thicknesses of 7/16 of an inch or more, a greater percentage of short lengths, 5 to 10 feet, will be permitted. A greater percentage of short lengths (5 to 10 feet) will also be permitted for pipe.

3.5.4 Ends. Tube shall be furnished with sawed or machine cut and deburred ends, unless ends beveled for welding or threaded ends are specified in the order.

3.6 Marking. Material shall be marked in accordance with 3.6.1.

3.6.1 Commercial marking. Unless otherwise specified (see 6.2), the name or trademark of the manufacturer and the type shall be legibly marked on each tube of five-eighths of an inch outside diameter or larger. The marking fluid used shall be capable of being removed with hot alkaline cleaning solution without rubbing. The marking shall have no deleterious effects on the material or its performance, and the characters shall be sufficiently stable to withstand ordinary handling and storage. On sizes smaller than five-eighths of an inch outside diameter, the above information shall be marked on the shipping container. When continuous identification marking is specified, marking shall conform with the requirements of Fed. Std. No. 182 and shall be designated "seamless" or "welded" as applicable, after "class".

3.7 Workmanship.

3.7.1 Tube or pipe up to and including 5 inch O.D. shall be seamless drawn. Tubes larger than 5 inch O.D. shall be seamless drawn or formed from sheets and welded.

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3.7.2 The surface of all tube or pipe shall be smooth, clean and free from cracks, laminations, laps, screws, scale and other injurious defects to the maximum extent possible as revealed by visual examination. The tube shall be free of burrs with ends cut square and shall be of proper dimensions. Surface imperfections such as handling marks, straightening marks, light mandrel, and die or roll marks will not be considered injurious defects, provided the imperfections do not reduce the wall thickness below the minimum specified in 3.5.

3.7.3 Tubing may be ground to remove minor defects provided such grinding does not reduce the wall thickness below the minimum permissible. Welded tubing shall not contain more than one longitudinal and one circumferential weld in each length. Unless otherwise specified (see 6.2), an individual tube having a surface irregularity in which the depth is greater than 10 percent of the wall thickness or 0.001 inch, whichever is greater as determined by visual examination, shall be rejected.

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

#### 4.2 Lot definition.

4.2.1 Chemical analysis. A lot shall consist of all material made from the same heat or melt.

4.2.2 Visual and dimensional examination, defect inspection, and mechanical properties tests. A lot shall consist of all material from the same heat, of the same size, from the same heat treatment batch, or from a continuous process under the same conditions of temperature, time at heat, and atmosphere.

#### 4.3 Sampling.

4.3.1 Examination. Unless otherwise specified (see 6.2), sampling for examination shall be conducted in accordance with MIL-STD-105 at inspection level III. The acceptable quality level shall be 0.10 rejects per hundred units for major defects and 1.0 rejects per hundred units for minor defects.

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4.3.2 Sampling for chemical analysis. Unless otherwise specified (see 6.2), the manufacturer may submit a ladle analysis as proof that the pipe and tubing submitted, meets the requirement of table I.

4.3.2.1 Alloy identity. Each random mill length prior to shipping shall be tested for alloy identity by a method, such as metal-sorter, check spectrograph, wet chemical analysis, approved by the contracting officer (see 6.2).

4.3.3 Sampling for test. Sampling for tests shall be made in accordance with table IV. Failure of any test specimen, where sampling is involved, to meet the test requirements shall reject the lot represented.

Table IV. Test schedule

Test	No. of test samples <sup>1</sup>	Test Method <sup>2</sup>	Reference paragraph
Chemical analysis	1	111.1 or 112.1	- - - -
Tension test & elongation Classes A and B	1	211	4.5.1.1
Classes C and D (circumferential weld)	2	211	4.5.1.2 and 4.5.1.3
Flattening test (Class A)	1	---	4.5.2
Bending test (Class C)	1	---	4.5.3
Flare test (Classes A & C only)	1	---	4.5.4
Hydrostatic test	See note 3	---	- - - -

<sup>1</sup> When the material in the lot cannot be identified by the melt, one sample for each test shall be selected from each 500 pounds of material in the lot.

<sup>2</sup> Test methods are found in Federal Test Method Std. No. 151.

<sup>3</sup> Each length of pipe or tube shall be subjected to the hydrostatic test described in 3,4,5.



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4.4 **Examination.** Examination shall be conducted as specified in table V. Any tube or pipe in the sample containing one or more defects shall be rejected, and if the number of defective tube or pipe in any sample exceeds the acceptance number for that sample, the lot represented by the sample shall be rejected.

Table V. Classification of defects in accordance with MIL-STD-105

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Major:

101	Dimensions not as specified.
102	Ends not as specified.
103	Ends not free from burrs.
104	Material not processed as required; surface defects, such as pipes, laps, checks, pits, surface tears, twists, scales, etc. exceed the allowable limits.
105	Tube ovality not within tolerances.
106	Welded tubing reinforcements beyond permissible variation.
107	Welded tubing has more than one longitudinal or circumferential weld in each length.

Minor:

201	Marking not as specified.
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4.5 **Tests.** Samples selected in accordance with 4.3.3 shall be tested as indicated in table IV and in the applicable referenced paragraph.

4.5.1 Tension test and elongation.

4.5.1.1 Classes A and B seamless tube or pipe. One longitudinal tension test specimen shall be cut from each tube selected in accordance with 4.3.3. Where practicable, tube or pipe shall be tested in full section with the ends plugged to prevent collapsing in the grips of the testing machine. The form and dimensions of the test specimen and plugs shall be as shown in figure 1 of Method 211 of Fed. Test Method Std. No. 151. For tube whose diameter does not permit testing in full size, test specimens shall be cut longitudinally from the sample tube and prepared as a figure 5 specimen of Method 211 of Fed. Test Method Std. No. 151.

4.5.1.2 Classes C and D welded tube. A tension test specimen shall be cut circumferentially from one end, straightened when hot,

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and machined to shape and to a width of 1-1/2 inches. The longitudinal weld shall be at the midlength of the test specimen. The weld reinforcement shall be removed flush with the tube before testing. The gage length for measuring elongation of the tension test specimen shall be 16 times the thickness of the specimen. Since the test specimens are bent hot, properties may be those of the annealed material.

4.5.1.3 Classes C and D circumferential weld. For welded tube containing a circumferential weld, two tension specimen, taken at opposite sides of the tube, shall be removed longitudinally with the circumferential weld at the midlength of the specimen. The specimen shall be flattened cold and machined to a width of 1-1/2 inches. The weld reinforcement shall be removed flush with the tube on both sides.

4.5.2 Flattening test on Class A seamless tube. Specimen selected in accordance with 4.3.3 shall be flattened cold between parallel plates under a gradually applied load until the distance between the plates is five times or less than the wall thickness. The specimen shall show no injurious defects.

4.5.3 Bend test on Class C, welded tube. Test samples selected in accordance with 4.3.3 shall be prepared for the root bend test. A strip 1-1/2 inches wide by 10 inches long with the weld at midlength shall be cut circumferentially from the sample and flattened hot. The weld reinforcement shall be removed from both sides of the weld. The test specimen shall be bent in a guided-bending jig as specified in ASTM E190 while the root of the weld inside the tube is in tension.

4.5.4 Flare test on Classes A and C. The flare test shall be conducted on classes A and C annealed tube only. One flare test shall be made on the sample selected in accordance with 4.3.3. The test sample shall be flared with an expanding tool having an included angle of 60 degrees until the specified outside diameter has been increased by 30 percent.

4.6 Inspection of preparation for delivery. The packing and marking of the tube and pipe shall be inspected in conformance with the requirements of section 5 of this specification.

## 5. PREPARATION FOR DELIVERY

5.1 Packing. Packing shall be level A, B, or C, as specified (see 6.2).

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5.1.1 Levels A and B. The tube and pipe shall be packed in accordance with the applicable level A or B requirements of MIL-C-3993.

5.1.2 Level C. The tube and pipe shall be packed in a manner which will insure arrival at destination in satisfactory condition and be acceptable to the carrier at lowest rates. Containers and packing shall comply with Uniform Freight Classification Rules, or with rules and regulations of other carriers, as applicable to the mode of transportation.

5.2 Marking. In addition to any special marking required by the contract or order, shipping containers shall be marked in accordance with the requirements of MIL-STD-129.

## 6. NOTES

6.1 Intended use. Tube or pipe covered by this specification is intended for use in applications where the strength and corrosion resistance of nickel-copper alloy (monel) are required.

6.2 Ordering data. Procurement documents should specify the following:

- (a) Title, number and date of this specification.
- (b) Class required (see 1.2).
- (c) Size, outside diameter, wall thickness and length required (see 1.3, 3.5.3, 6.5 and table VI).
- (d) If tubing is intended for silver brazing (see 3.5.1).
- (e) Ends, finish required (see 3.5.4).
- (f) If material marking is to be continuous (see 3.6).
- (g) Surface irregularities (see 3.7.3).
- (h) Sampling, if different (see 4.3.1 and 4.3.2).
- (i) Type of test required for performance of alloy identity (see 4.3.2.1).
- (j) Level of packing required (see 5.1).
- (k) If special requirements are necessary (see 6.5)

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6.3 Tubing which is to be bent in fabricating should be ordered at a thickness sufficient to assure the required wall thickness at the thinnest point of the tube.

## 6.4 Definitions of heat treatment.

6.4.1 Class A. Class A tube and pipe are produced by cold working followed by annealing. The tube or pipe is supplied with a dull matte finish.

6.4.2 Class B. Class B tube and pipe are thermally treated to relieve a major portion of the internal stresses and have a thin dark oxide surface.

6.4.3 Class C. Class C tube and pipe are formed from sheets or strip and welded. The material is annealed and has a dull matte finish.

6.4.4 Class D. Class D tube and pipe may be formed from sheet or strip and welded. The material is thermally treated to relieve a major portion of the internal stresses, and has a thin oxide surface.

6.5 The standard dimensions for commercially available pipe shown in table VI are for information only (see 1.3).

6.6 Nuclear end-use. When material is intended for nuclear applications, agreement shall be reached between the contractor and the Government, prior to placement of the order, as to applicable nonstandard or nondestructive test requirements, as well as to details of testing techniques and standards for acceptance and rejection.

6.7 Classification change. The following tube and pipe were formerly classified in MIL-T-1368B as indicated below:

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Class A  
Class B  
Class C  
Class D

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Type I, condition 1  
Type I, condition 2  
Type II, condition 1  
Type II, condition 2

## Custodians:

Army - MR  
Navy - YD  
Air Force - 69

## Review activities:

Army - MR, MO, MI  
Navy - YD, WF, SH  
Air Force - 69

## User activities:

Army - WC, MU  
Navy - None  
Air Force - None

Preparing activity:  
Navy - YD

(Project No. 4710-0102)

Table VI. Commercial, available pipe sizes

Nominal Pipe Size inch	Schedule No. 5		Schedule No. 10		Schedule No. 40		Schedule No. 80		
	O. D. inch	Nominal Wall thickness inch	Wt./Ft.	Nominal Wall thickness inch	Wt./Ft.	Nominal Wall thickness inch	Wt./Ft.	Nominal Wall thickness inch	
1/8	0.405	-----	-----	0.049	.2098	0.068	0.3542	0.095	.3542
1/4	0.540	-----	-----	0.065	.3713	0.088	0.6025	0.119	.6025
3/8	0.675	-----	-----	0.065	.4768	0.091	0.8319	0.126	.8319
1/2	0.840	0.065	.6058	0.083	.7556	0.109	1.2251	0.147	1.2251
3/4	1.050	0.065	.7700	0.083	.9652	0.113	1.6594	0.154	1.6594
1	1.315	0.065	.9771	0.109	1.5809	0.133	2.4454	0.179	2.4454
1-1/4	1.660	0.065	1.2468	0.145	2.0331	0.140	3.3742	0.191	3.3742
1-1/2	1.900	0.109	1.4344	0.145	2.3471	0.200	4.0888	0.200	4.0888
2	2.375	0.065	1.8057	0.109	2.9703	0.154	5.6549	0.218	5.6549
2-1/2	2.875	0.083	2.7869	0.120	3.9758	0.203	8.6265	0.276	8.6269
3	3.500	0.083	3.4107	0.120	4.8777	0.216	11.5450	0.300	11.5450
3-1/2	4.000	0.083	3.9098	0.120	5.5993	0.226	14.0810	0.318	14.0810
4	4.500	0.083	4.4089	0.120	6.3209	0.237	16.8716	0.337	16.8716
5	5.563	0.109	7.1493	0.134	8.7487	0.258	23.3966	0.375	23.3966
6	6.625	0.109	8.5414	0.134	10.4601	0.280	32.1741	0.432	32.1741
8	8.625	-----	-----	-----	-----	0.322	48.8556	0.500	48.8556

Schedule 160

Nominal Pipe Size inch	O. D.		I. D.		Wall Thickness		Weight per ft.
	inch	inch	inch	inch	inch	inch	
1/2	.840	.466	.187	1.4685			
3/4	1.050	.614	.218	2.1812			
1	1.315	.815	.250	3.2019			
1-1/4	1.660	1.160	.250	4.2392			
1-1/2	1.900	1.338	.281	5.4711			
2	2.375	1.689	.343	8.3818			
2-1/2	2.875	2.125	.375	11.2744			
3	3.500	2.624	.438	16.1287			
4	4.500	3.438	.531	25.3453			
5	5.563	4.313	.625	37.1152			

Double extra heavy

Nominal Pipe Size inch	O. D.		I. D.		Wall Thickness		Weight per ft.
	inch	inch	inch	inch	inch	inch	
3/4	1.050	.434	.308	2.7484			
1	1.315	.599	.358	4.1202			
1-1/4	1.660	.896	.382	5.8710			
1-1/2	1.900	1.100	.400	7.2156			
2	2.375	1.503	.436	10.1668			
2-1/2	2.875	1.771	.552	15.4209			
3	3.500	2.300	.600	20.9252			

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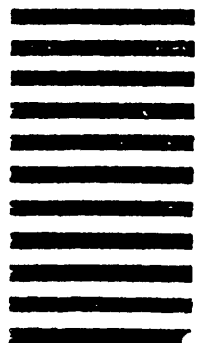
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