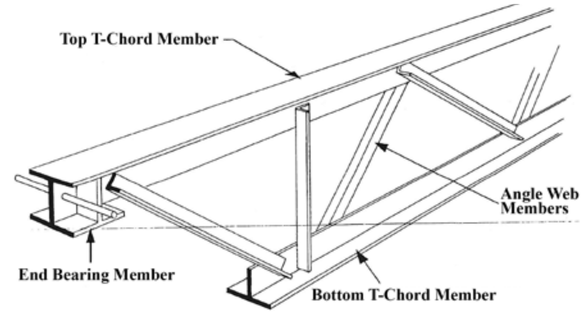
Antiquated Structural Systems Series

Part 9a – Open Web Steel Joists

By D. Matthew Stuart, P.E., S.E., F. ASCE, SECB



For this series of articles, "antiquated" has been defined as meaning outmoded or discarded for reasons of age. In reality, however, most of the systems that have been discussed are no longer in use simply because they have been replaced by more innovative or more economical methods of construction.

This article, however, deals with a method of construction that is still very much in use today. Nevertheless, the historic, original construction practices described in this article may still be encountered in existing structures. Therefore, the primary purpose of this series of articles will be fulfilled: to compile and disseminate a resource of information to enable structural engineers to share their knowledge of existing structural systems that may no longer be in use, but are capable of being adapted or reanalyzed for safe reuse in the marketplace of today and the future.

Open Web Steel Joists

History

The author would first like to thank the Steel Joist Institute (SJI) for providing much of the material that was used in the development of this article. In fact, a brief history of open web joists is provided in the *Catalog of Standard Specifications and Load Tables for Steel Joists and Joist Girders*, published by SJI. A brief summary of this history is as follows:

1923 The first Warren type, open web truss/joist is manufactured using continuous round bars for the top and bottom chords, with a continuous bent round bar used for the web members.

1928 First standard specifications adopted after the formation of SJI. This initial type of open web steel joists was later identified as the SJ-Series.

1929 First load table published.

1953 Introduction of the longspan or L-Series joists for spans up to 96 feet with depths of up to 48 inches, which were jointly approved by AISC.

1959 Introduction of the S-Series joists, which replaced the SJ-Series joists. The allowable tensile strength was increased from 18 ksi to 20 ksi, and joist depths and spans were increased to 24 inches and 48 feet, respectively.

1961 Introduction of the J-Series joists, which replaced the S-Series joists. The allowable tensile strength was increased from 20 ksi to 22 ksi. Introduction of the LA-Series joists to replace the L-Series joists, which included an allowable tensile strength increase from 20 ksi to 22 ksi. Introduction of the H-Series joists, which provided an allowable tensile strength of 30 ksi.

1962 Introduction of the LH-Series joists, which provided yield strengths between 36 ksi and 50 ksi.

1965 Development of a single specification for the J- and H-Series joists by SJI and AISC.

1966 Introduction of the LJ-Series joists, which replaced the LA-Series joist. In addition, a single specification was developed for the LJ- and LH-Series joists.

1970 Introduction of the DLH- and DLJ-Series joists, which included depths up to 72 inches and spans up to 144 feet.

1978 Introduction of Joist Girders, including standard specifications and weight tables.

1986 Introduction of the K-Series joists, which replaced the H-Series joists.

1994 Introduction of the KCS joists, which provided a constant moment and shear capacity envelope across the entire length of the member.

SJI also recently published *80 Years of Open Web Steel Joist Construction*. This publication includes a complete chronological listing of the standard specifications and load tables for all of the steel joists, and weight tables for the Joist Girders, previously made available by SJI over the time period from 1928 to 2008. This manual can be an invaluable tool for an engineer involved in the analysis of existing buildings constructed with open web steel joists.

In addition, there were also a number of joists produced by manufacturers that were either never members of SJI or joined it later. Some of these manufacturers in-clude: Ashland Steel Joists (manufactured by Ashland Steel Products Co., Inc – Ashland City, Tennessee); Vescom Structural Systems, Inc. – Westbury, New York; Ridgeway Joists (manufactured by Continental Steel Ltd. – Coquitlam, British Columbia); Northwest Joist Limited (a Division of Brittain Steel Limited – New Westminster, British Columbia); Cadmus Long Span and Joist Corporation (affiliated with Alexandria Iron Works, Inc. – Alexandria, Virginia); T-Chord Longspan Joists (manufactured by the Haven Busch Company – Grandville and Grand Rapids, Michigan); and the Macomber Steel Company – Canton, Ohio. *Table 1 (please see online version; article end note provides web address)* provides a summary description of the joists produced by these manufacturers.

In addition, some manufacturers, prior to becoming SJI members, produced products other than the historical standard SJI joist series. Some of these manufacturers include: Truscon Steel Company – Youngstown, Ohio; Macmar and Kalmantruss joists (manufactured by Kalman Steel Corporation, a Subsidiary of Bethlehem Steel Company – Bethlehem, Pennsylvania); and Gabriel Steel Company – Detroit, Michigan. *Table 2 (please see online version; artcile end note provides web address)* provides a summary description of the joists produced by these manufacturers. In addition to the information provided in *Table 2*, it should be noted that Bethlehem Steel Company also produced cold formed joists with hat channel sections for the chord members, and Gabriel Steel Company also produced unique V-shaped top chord and single round bar bottom chord members.

Additional manufacturers not included in *Tables 1* and *2* include: Berger Steel Company (double V-shaped chord members); Armco Steel (cold formed hat channel chord members); Raychord Corporation (cold formed hat channel and U-shaped chord members); Republic Steel (cold formed hat channel chord members); and USS AmBridge (cold formed U-shaped chord members).▪

Resource Material

80 Years of Open Web Steel Joist Construction; *A Compilation of Specifications and Load Tables Since 1928*; Steel Joist Institute; Myrtle Beach, South Carolina (2009).

Catalog of Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders; 42nd Edition; Steel Joist Institute; Myrtle Beach, South Carolina (2007).

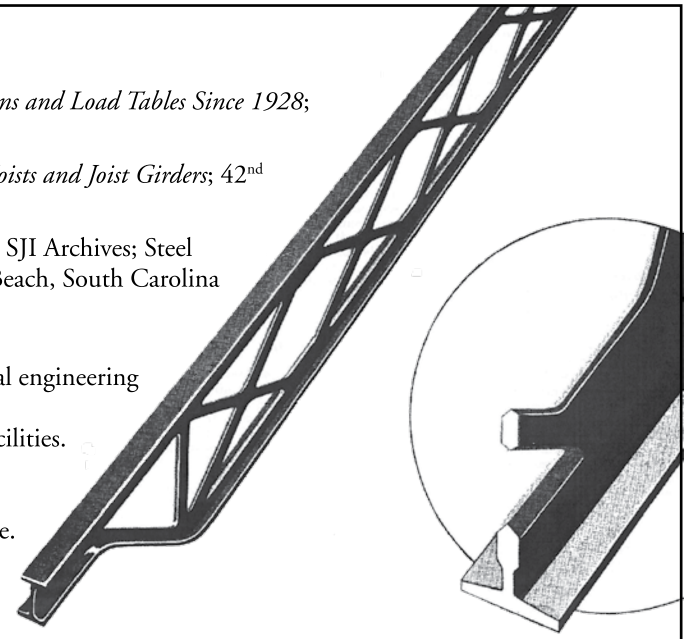
Miscellaneous Steel Joist and Joist Girder Specifications and Load Tables; SJI Archives; Steel Joist Institute, Technology, Engineering, and Education Center; Myrtle Beach, South Carolina

Another Resource

Robert Higgins, P.E., maintains a website that provides civil and structural engineering information in the following categories:

- Out-of-print material that may be useful when working on existing facilities.
- Older, usually conservative methods for solving technical problems.
- Public domain documents that have limited availability.

In summary, this is content that is difficult to find anywhere else. To access it, visit **www.SlideRuleEra.net**.

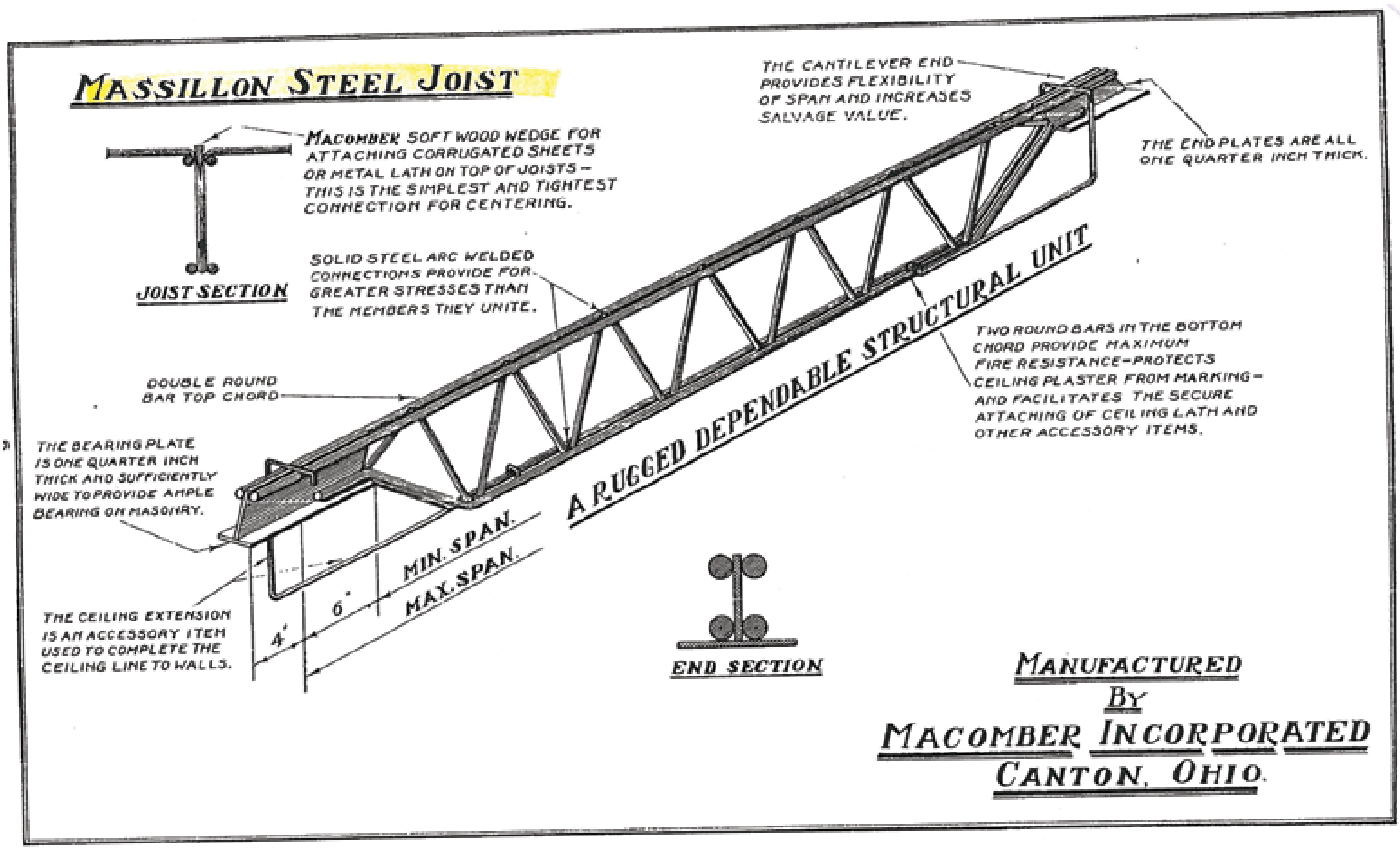


D. Matthew Stuart, P.E., S.E., F. ASCE, SECB is licensed in 20 states. Matt currently works as a Senior Project Manager at the main office of CMX located in New Jersey, and also serves as Adjunct Professor for the Masters of Structural Engineering Program at Lehigh University, Bethlehem, PA. Mr. Stuart may be contacted at ***mstuart@CMXEngineering.com****.*

Watch for Part 9b in an upcoming issue.

Table 1 online version web address: www.STRUCTUREmag.org/archives/2009-6/table-1.pdf

Table 2 online version web address: www.STRUCTUREmag.org/archives/2009-6/table-2.pdf



Antiquated Structural Systems Series - Table 1

Part 9a – Open Web Steel Joists

By D. Matthew Stuart, P.E., S.E., F. ASCE, SECB

Table 1: Unique Open Web Joists (Load Tables may be available from SJI)

System	Figure	Description	Yield Strength	Depth (inches)	Span (feet)	Chords	Webs	Notes
Ashland	1	HS-Series Joists	50 ksi	8 to 24	8 to 48	Double angles	Round bars	
	N/A	LS-Series Joists	50 ksi	Unknown	64 maximum	Unknown	Unknown	
Cadmus	5	1952 Structural T Longspan & Standard Joists	See Note 6	10± to 54	12'-6" to 108	Split T	Angles	6, 7
Haven Busch	6	1952 to 1962 T-Chord Longspan Joists	See Note 9	18 to 88	25 to 175	Split T	Angles	8, 9
Macomber	7	Purlin or Steel Joist	Unknown	8 to 16	10 to 26	See Note 10	Round bars	10
	8	Massillon Steel Joist	Unknown	8 to 16	4 to 31	Round bars	Round bars	
	9	Canton Steel Joist	Unknown	8 to 16	Unknown	Double angles	Round bars	
	10	Buffalo Steel Joist	Unknown	8 to 16	Unknown	See Note 11	Round bars	11
	N/A	Special Joists	Unknown	12 to 20	8 to 40	Unknown	Unknown	
	11	Residence Joist	Unknown	6 to 10	6 to 20	See Note 12	Round bars	12
	12	Standard Longspan Joist	See Note 14	18 to 40	24 to 72	Double angles	Angles & bars	13, 14
	N/A	Intermediate Longspan	See Note 14	18 to 22	20 to 44	See Note 10	Round bars	10, 14
	13	1955 New Yorker	Unknown	8 to 24	7 to 48	V shaped plates	Round bars	
	14	V or Double V Bar Joist	Unknown	8 to 22	4 to 44	V shaped plates	Round bars	
	N/A	V-Girders	Unknown	18 to 48	13 to 96	V shaped plates	Round bars	
	15	V-Purlin	Unknown	8 to 60	8 to 120	V shaped plates	See Note 15	15
	16	Allspan	Unknown	8 to 76	8 to 152	V & Double V shaped plates	See Note 15	15
	N/A	V-Lok Purlin	Unknown	8 to 36	8 to 72	V & Double V shaped plates	Round bars or round pipes	16, 17
	17	V-Lok Girder	Unknown	12 to 40	15 to 50	See Note 18	Round bars or Angles	16, 18
	18	V-Beam	Unknown	8 to 28	8 to 56	See note 19	Round bars	19
Northwest	4	Series 1, 2, 3 & 4 Joists	See Note 5	12 to 72	12 to 80	V shaped plates	Square bars & round pipes	4, 5
Ridgeway	3	Open Web Joists	See Note 3	12± to 47±	16± to 59±	V shaped plates	Square bars & round pipes	3
Vescom	2	Composite Floor Joists	36 & 50 ksi	8 to 40	20 to 48	Double angles	Round bars	1
	N/A	Composite Truss Girders	36 & 50 ksi	16 to 40	20 to 50	Double angles	Angles	2

Notes:

1. Top chord included deformed, extended vertical leg of one angle for composite action with surrounding concrete slab.
2. Top chord included deformed, extended vertical plate in addition to double angles for composite action with surrounding concrete slab.
3. Web allowable stress: 36 ksi (bars) & 50 ksi (pipes); Chord allowable stress: 54 ksi.
4. Joist designs over 80 feet spans were available upon request.
5. Web allowable stress: 33 & 44 ksi (bars), 50 ksi (pipes); Chord allowable stress: 55 ksi.
6. Allowable compressive stress for top chord or web members = 15 ksi. Allowable combined compressive stress at top chord panel points and allowable tensile stress = 18 ksi.
7. Chord tees cut from standard wide flange or junior beams.
8. Available as parallel chord, single or double sloped top chord or hipped end configurations.
9. Allowable combined compressive stress at mid-panel chord and web = 15 ksi (1952); 20 ksi (1956). Allowable combined compressive stress at panel points = 24 ksi (1956). Allowable tensile stress = 20 ksi (1952 & 1956).
10. Double angle top chord; Round bars bottom chord.
11. Inverted double angle top chord; Round bars bottom chord.
12. Single steel angle and wood nailer top chord; Round bars bottom.
13. Available as parallel chord or single or double sloped top chord.
14. Allowable combined direct and bending stress in top chords = 20 ksi.
15. Sizes #2 - #9: Round bars; Sizes #10 up through #22: Angles.
16. Included proprietary stud and slot end bearing connection – See Figure 17.
17. Round bars, round pipes or angles.
18. V & double V shaped plates or double angles.
19. V shaped top chord & U shaped bottom chord plates.

Table 2: Unique Open Web Joists (Load Tables may be available from SJI)								
System	**Figure**	**Description**	**Yield Strength**	**Depth (inches)**	**Span (feet)**	**Chords**	**Webs**	**Notes**
Bethlehem	24	KalmanTruss Joists	See Note 8	8 to 16	4 to 32	T shape	Rectangular	7, 8, 9
	25	MacMar Joists	See Note 10	8 to 16	4 to 32	Angles	Round bars	10
	26	BLJ Series	See Note 11	52 to 60	89 to 120	Structural Tee	Angles	11
	26	BLH Series	See Note 12	52 to 60	89 to 120	Structural Tee	Angles	12
	27	Standard Open Web Joist	See Note 13	8 to 16	4 to 32	Angles	Round bars	13
	28	Longspan Open Web Joist	See Note 14	18 to 32	25 to 64	Angles	Angles	4, 14
	29	BJ Series	See Note 11	24 to 30	24 to 60	See Note 15	Round bars	11, 15
	29	BH Series	See Note 12	24 to 30	24 to 60	See Note 15	Round bars	12, 15
Gabriel	30	Long Span Joist		18 to 32	24 to 64	Angles	Round bars	4
Truscon	19 & 20	O-T (Open Truss) Joists	See Note 1	8 to 20	7 to 40	"Tee" & M shaped plates	Round bars	1
	21	Series AS Joists	See Note 2	8 to 24	7 to 48	U shaped	Round bars	2
	21	Series BB Joists	See Note 3	8 to 24	7 to 48	U shaped	Round bars	3
	22 & 23	Clerespan Joists	See Note 6	18 to 32	26 to 64	"Tee" & angles	Angles & bars	4, 5, 6

Notes:

1. Web allowable stress: 19,000 psi - 100(l/r); Chord allowable stress: 16,000 psi.
2. Cold formed chord allowable tension: 25 ksi; Hot rolled web members allowable compression: 17,000 psi - 100(l/r).
3. Cold formed chord allowable tension: 28.5 ksi; Hot rolled web members allowable compression: 19,000 psi - 100(l/r).
4. Available as parallel chord, single or double sloped top chord configurations.
5. Chord angles were some times arranged toe to toe for channel configuration.
6. Allowable combined top chord compressive stress: 15 ksi; Allowable bottom chord tensile stress: 18 ksi.
7. Manufactured by punching web opening in blanks such that chords and webs do not have to be welded together.
8. Allowable tensile stress: 16 and 18 ksi.
9. Also marked as Kalman Joist.
10. Allowable tensile stress: 18 ksi.
11. Maximum tensile working stress: 22 ksi.
12. Maximum tensile working stress: 30 ksi.
13. Design tensile stress: 18 ksi.
14. Allowable combined compressive stress at panel points and allowable tensile stress = 18 ksi. Allowable combined compressive stress at mid-panel and compression webs = 15 ksi.
15. Double angle top chord; Round bars bottom chord.

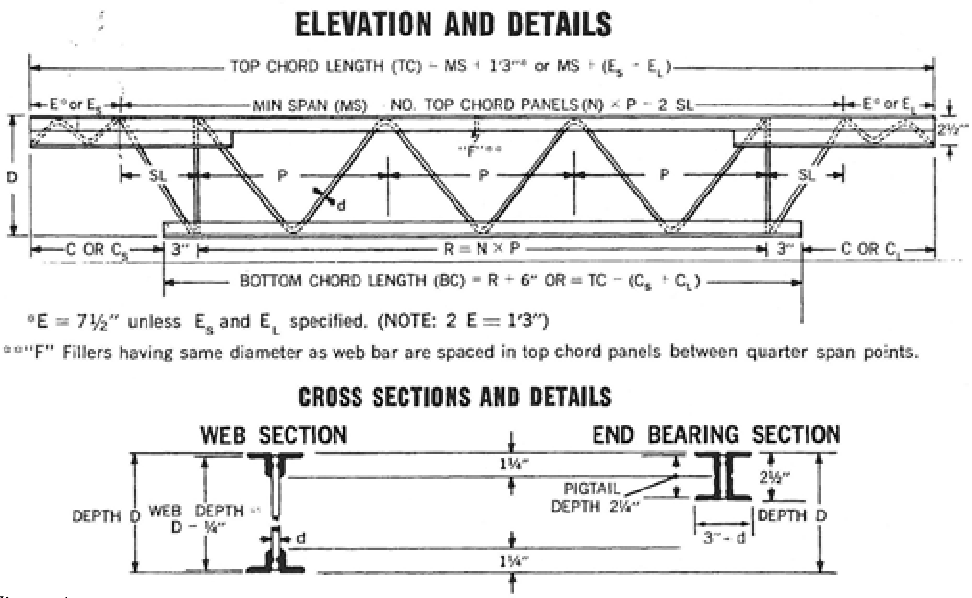


Figure 1

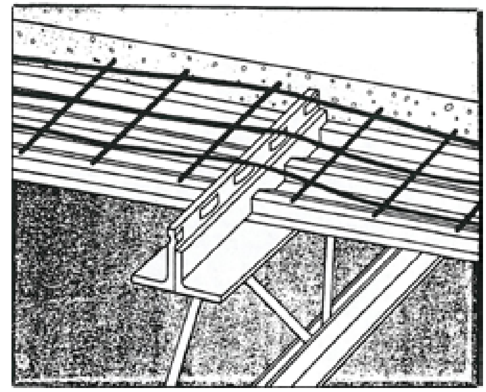
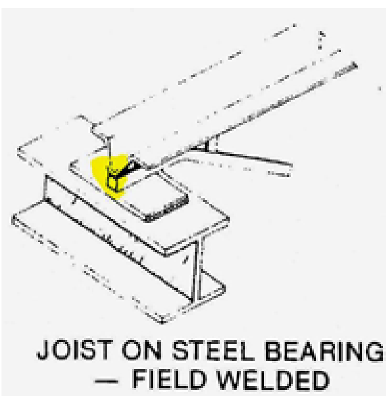


Figure 2



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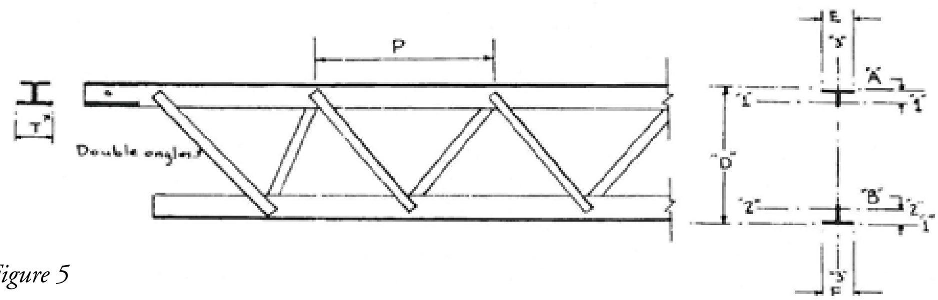

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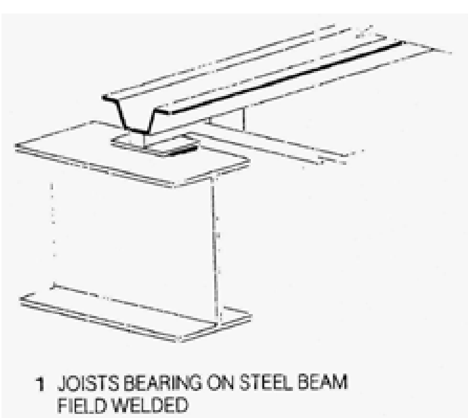

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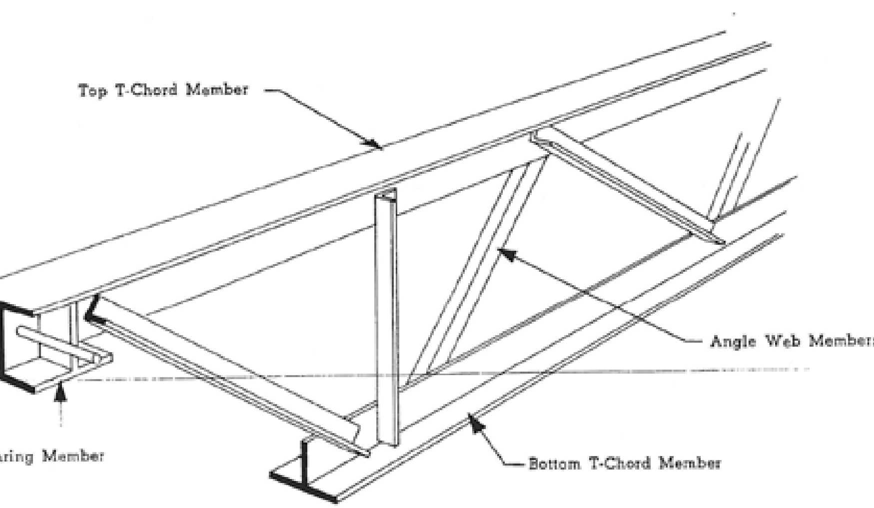
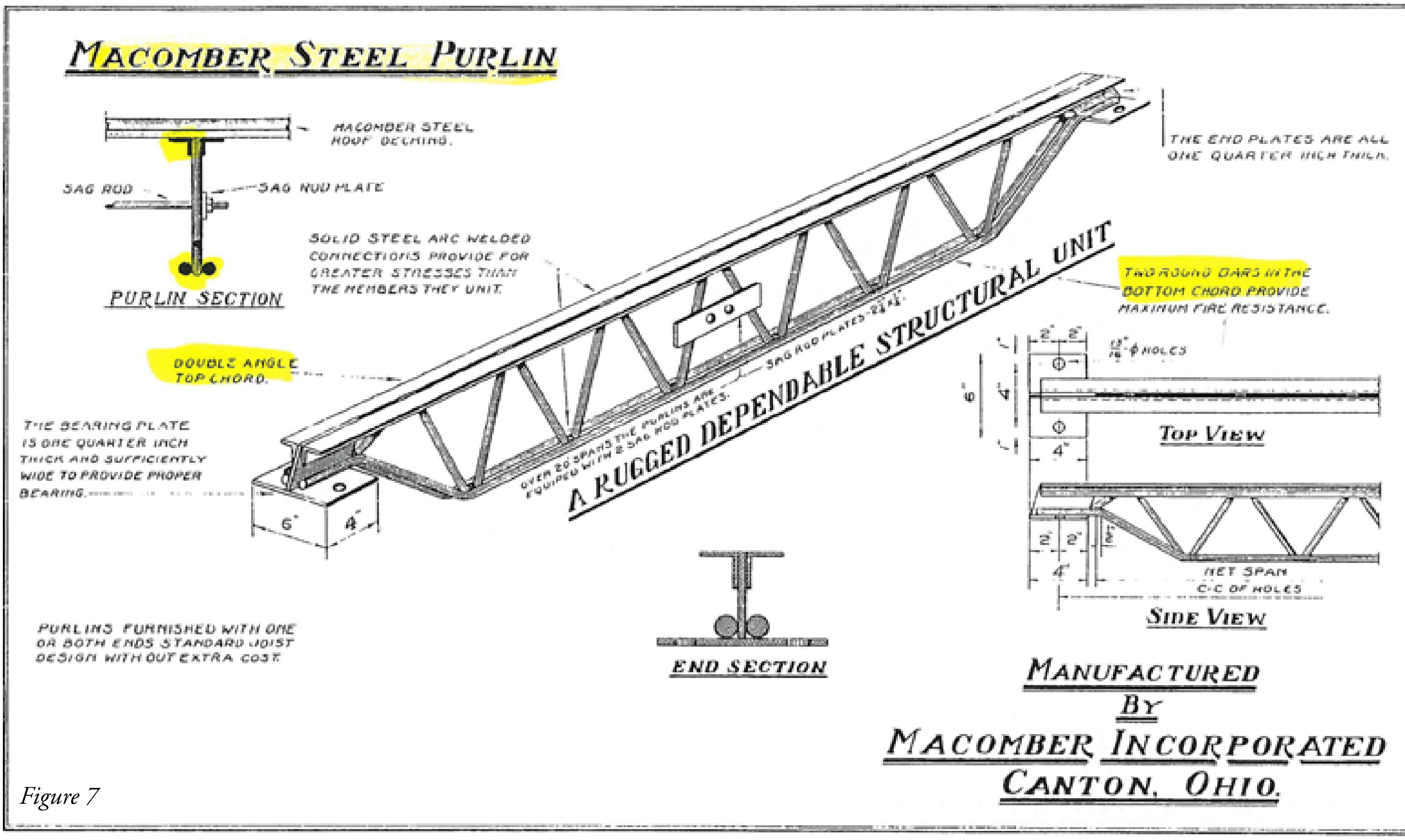


Figure 6

ALL WELDED CONSTRUCTION



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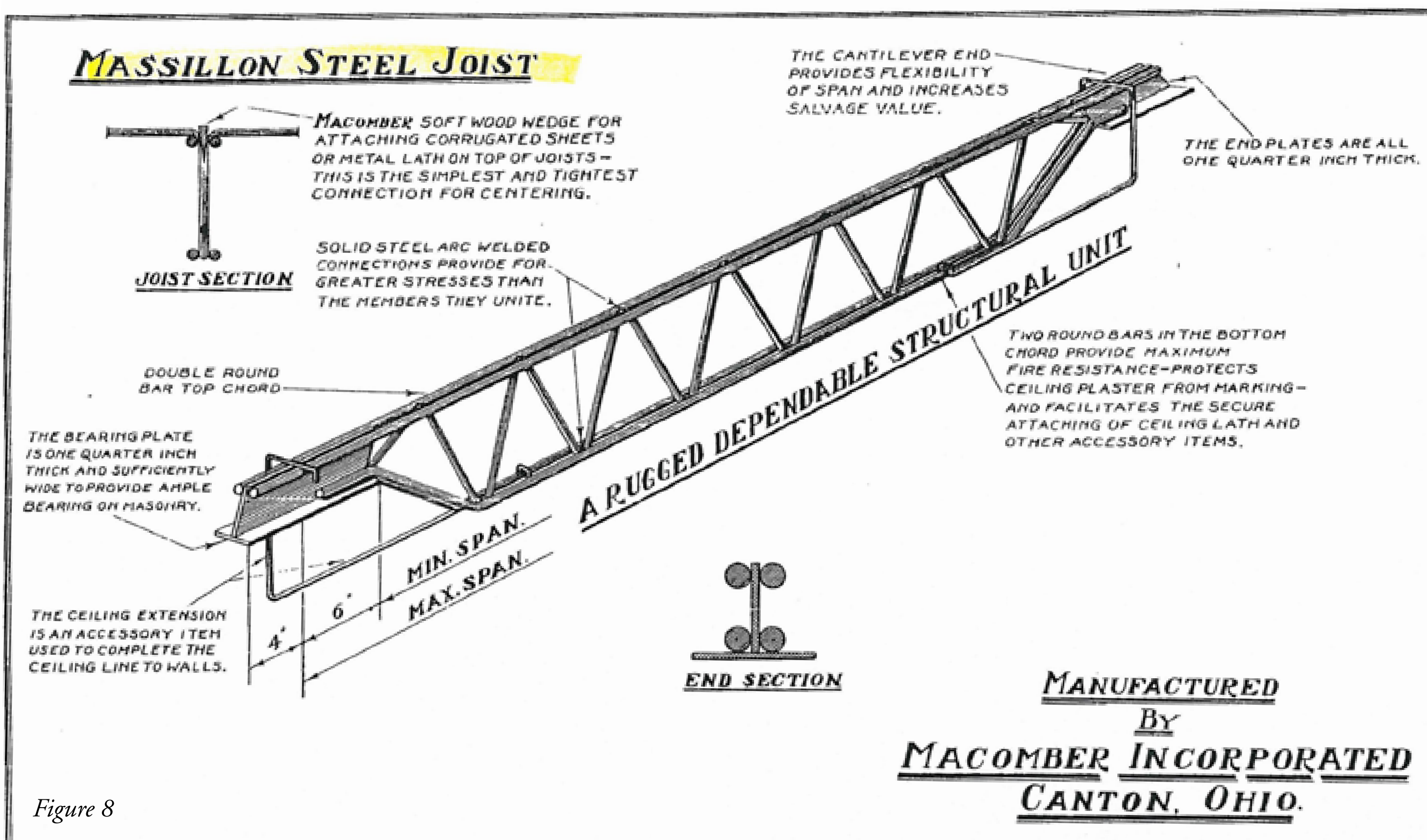

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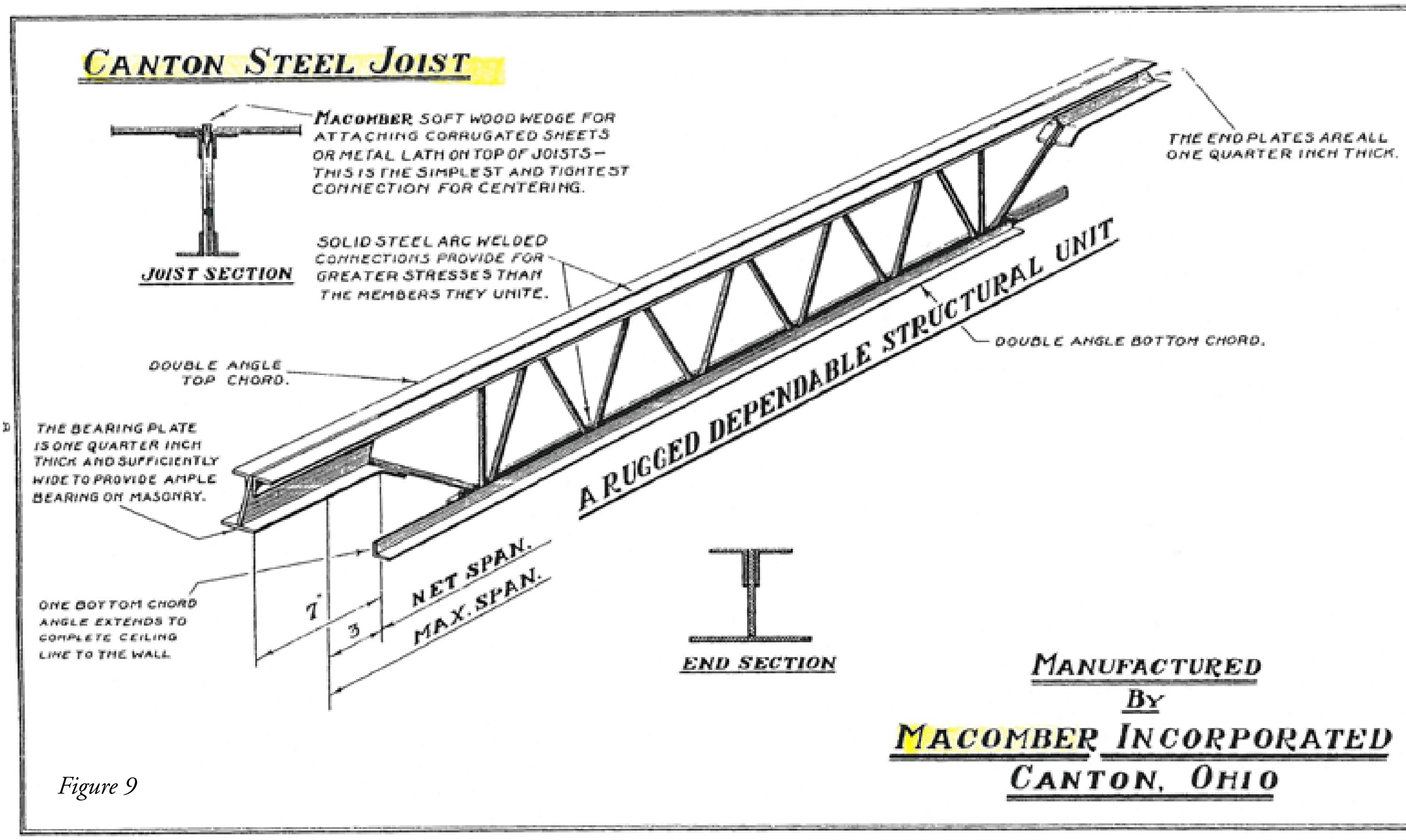

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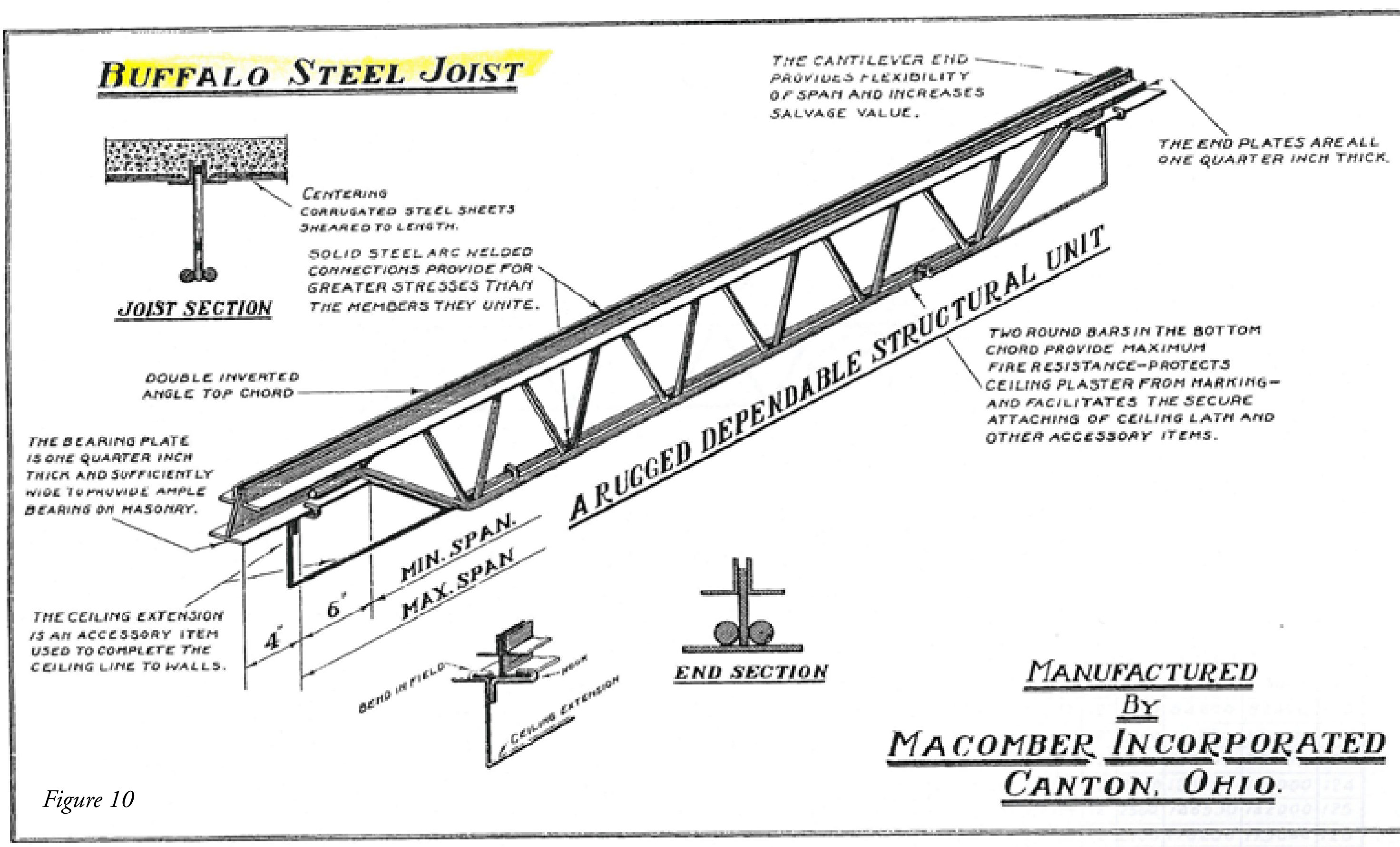

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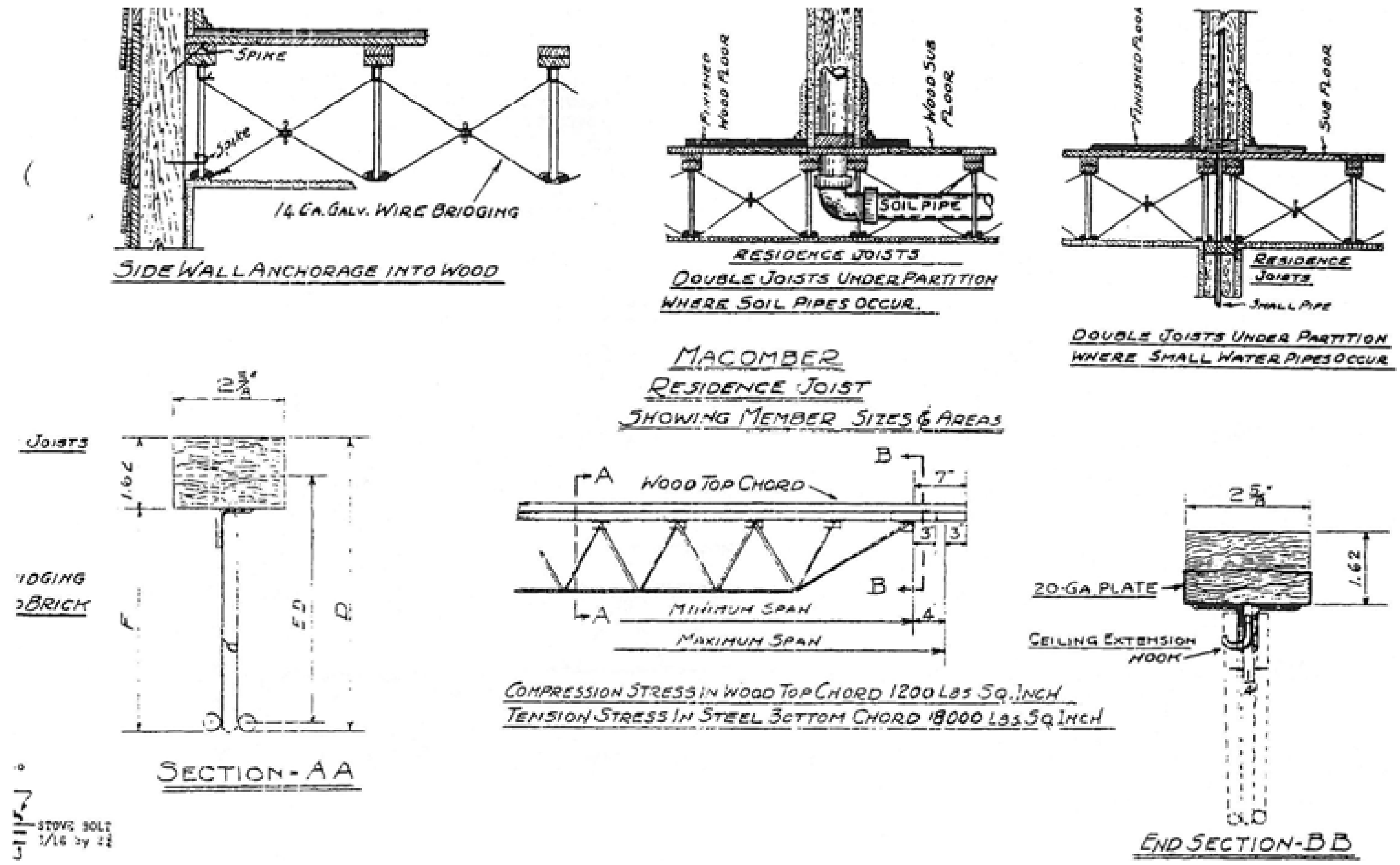

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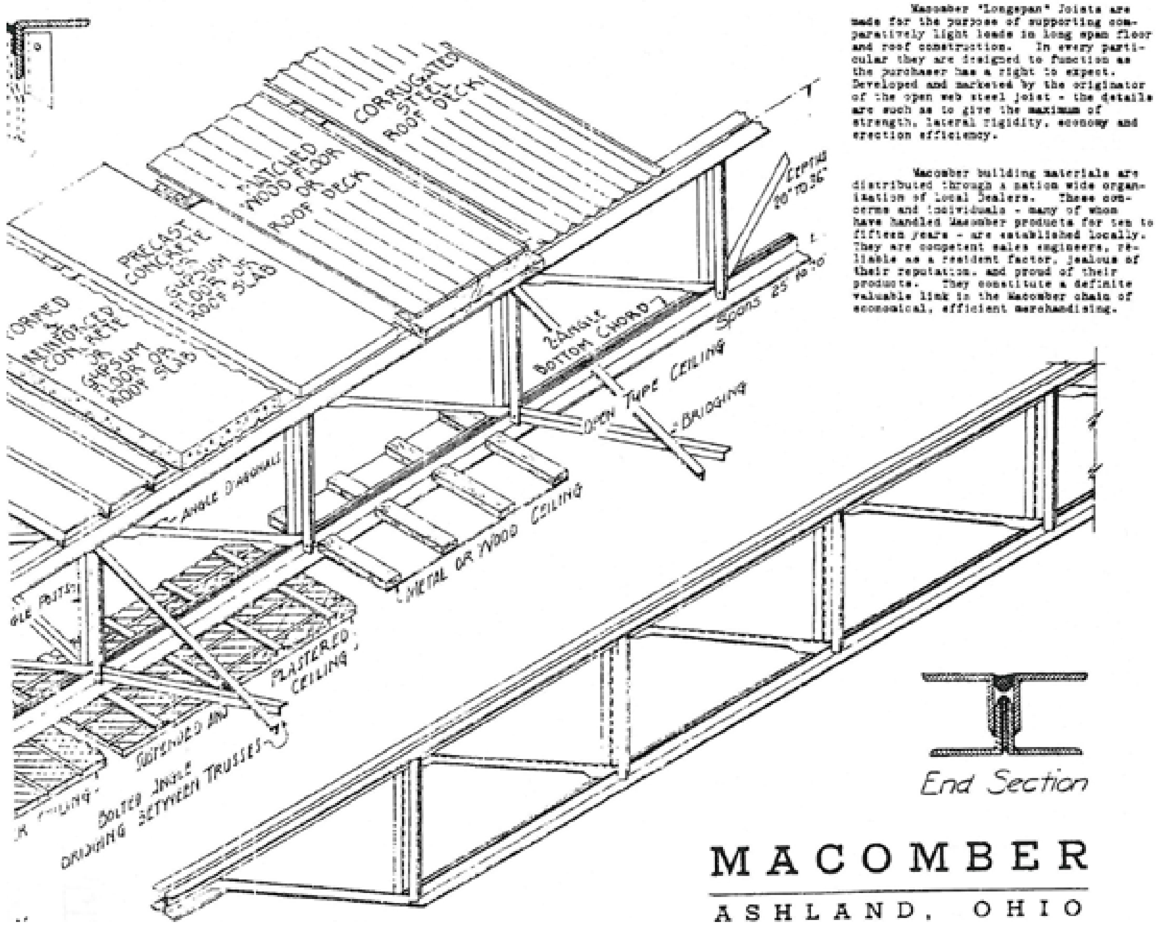

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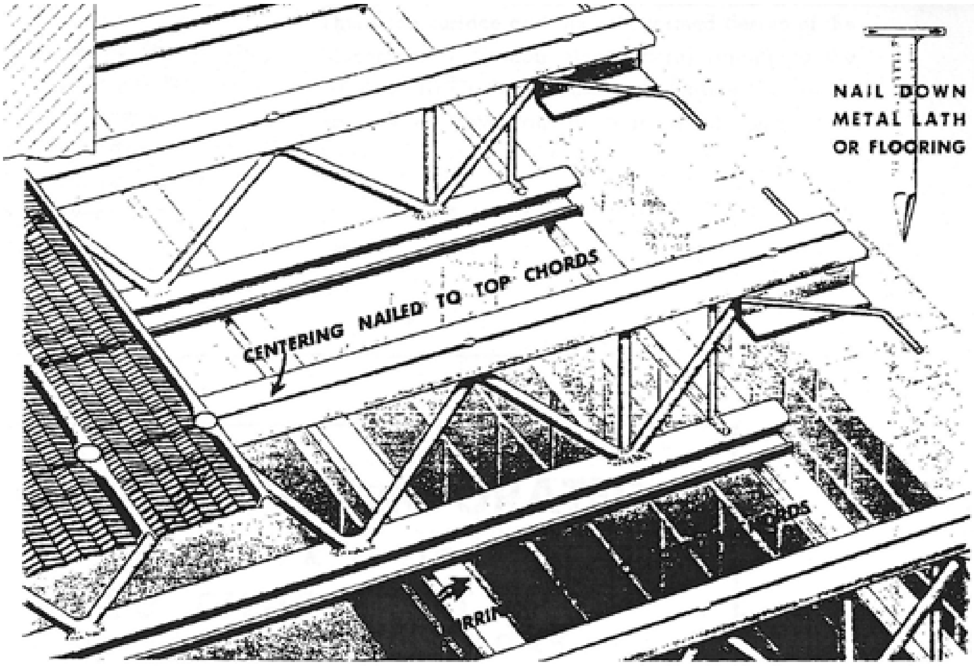

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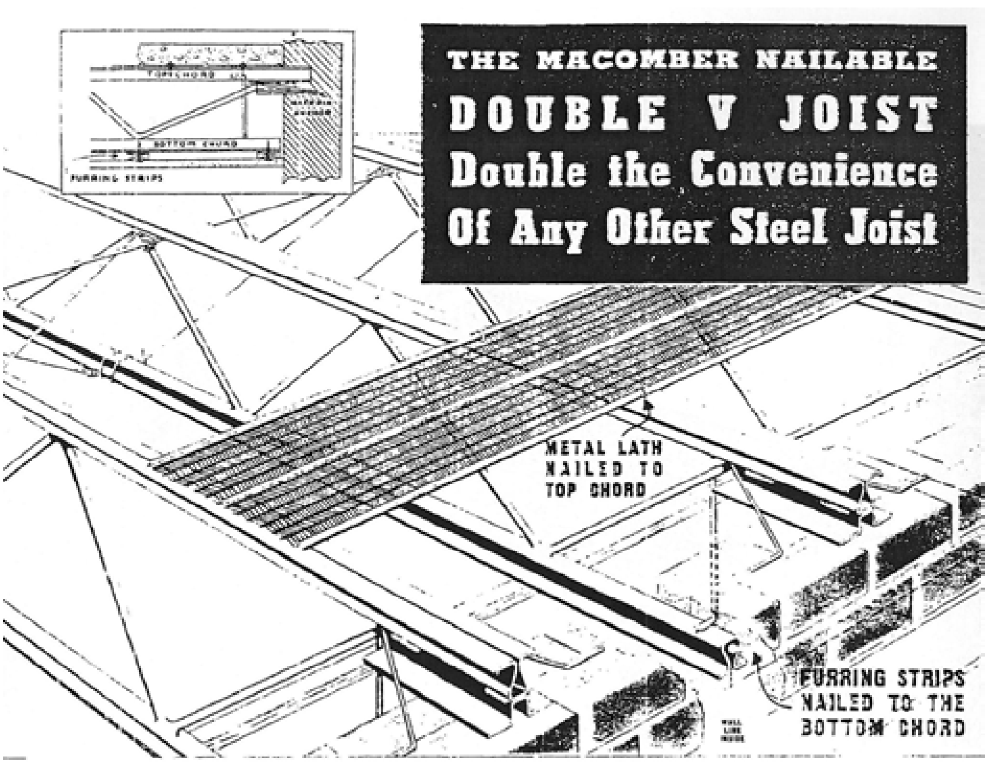

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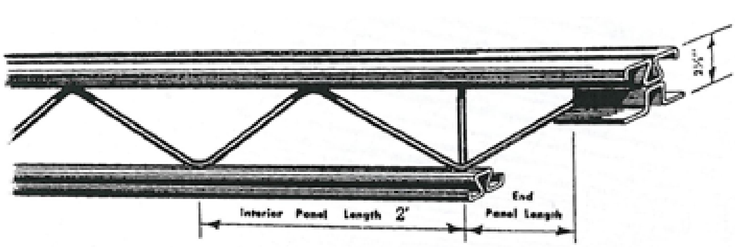
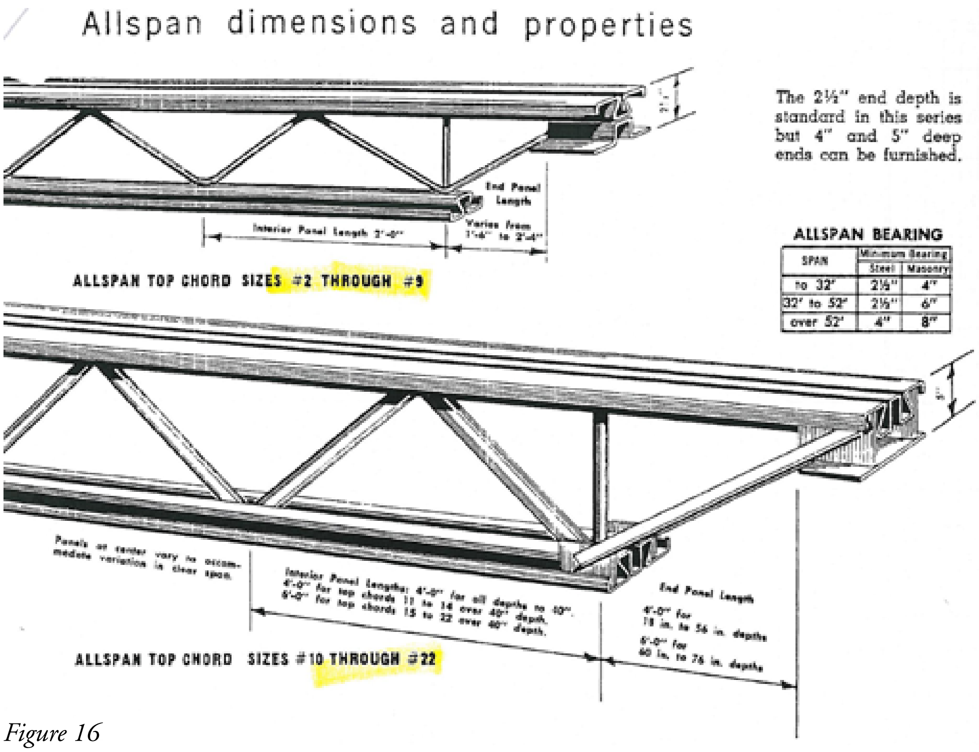


V-PURLIN TOP CHORD — SIZES #2 THROUGH #9

The 2½" end depth is standard in the No. 1 Series, but 4" and 5" deep ends can be furnished. All panel points in this series are on 2' centers.

Figure 15



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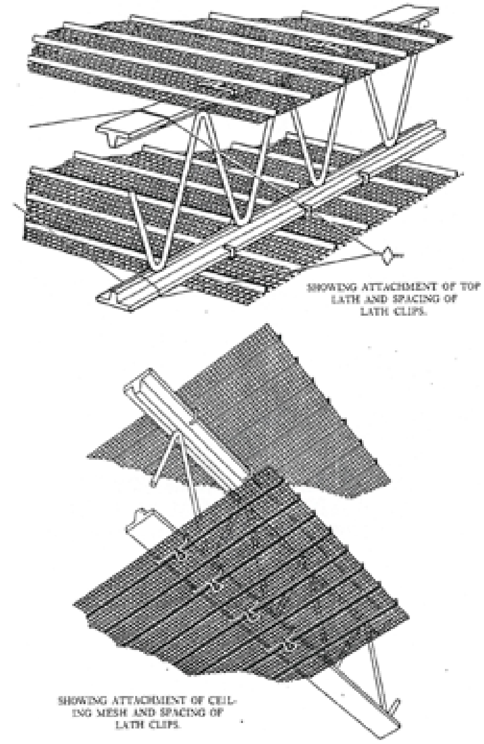

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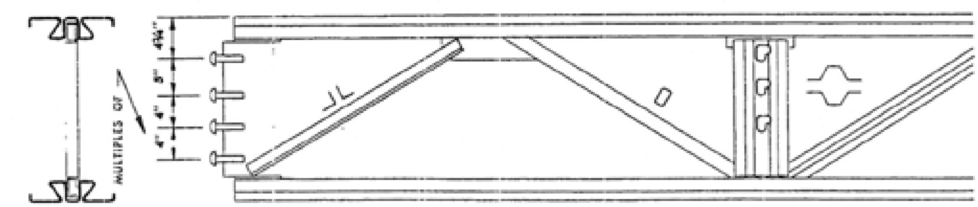

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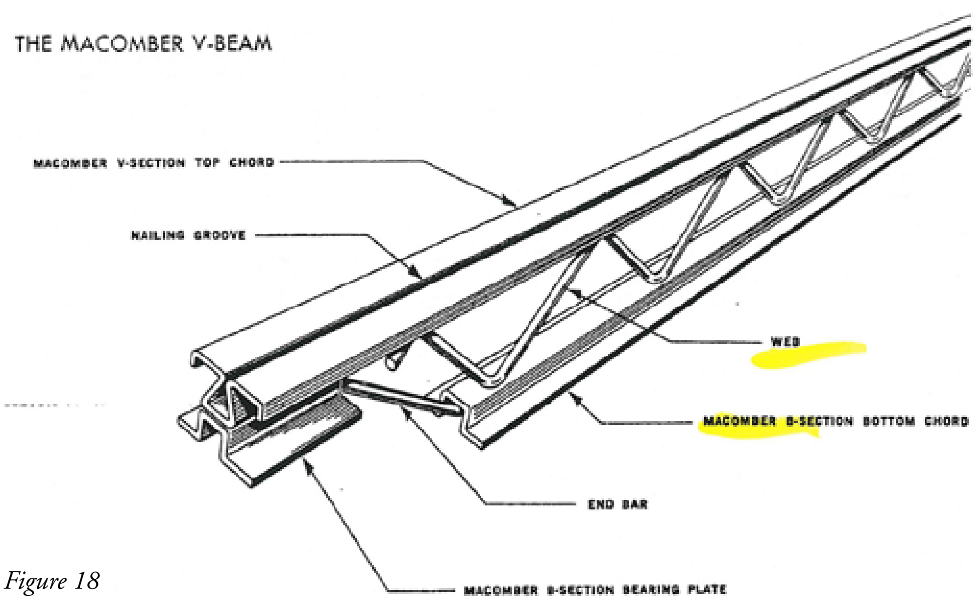

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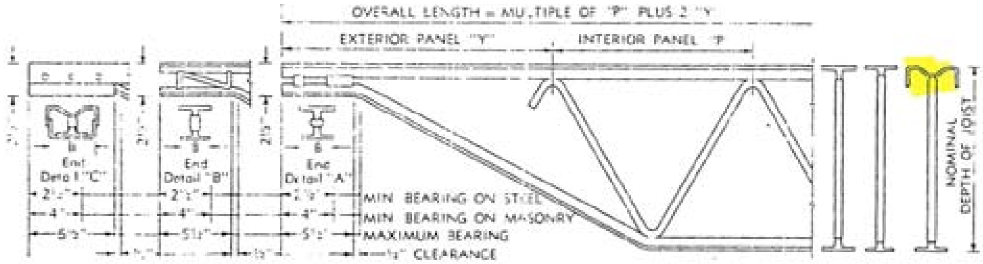

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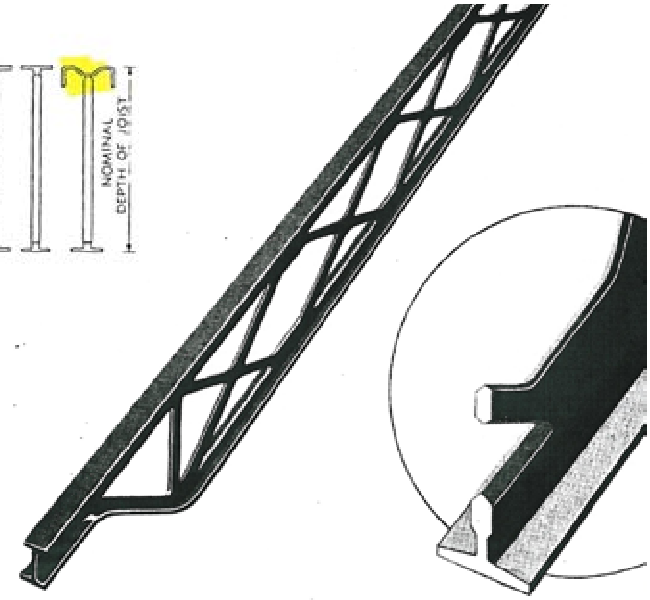

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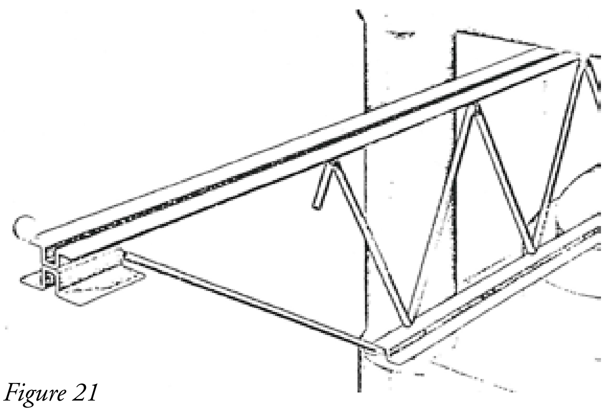

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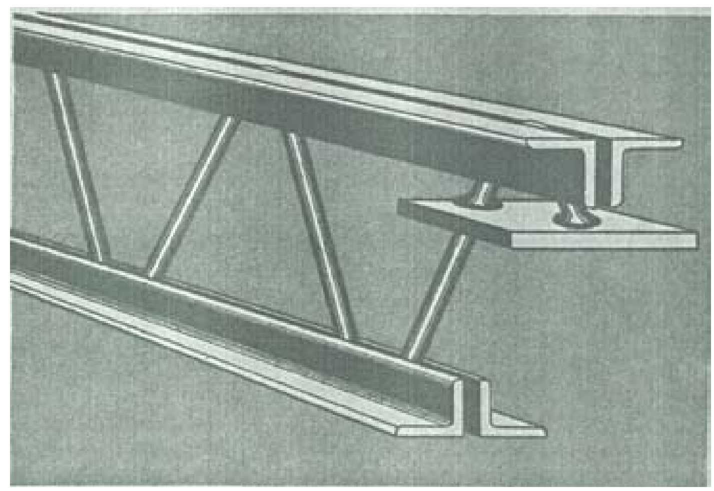

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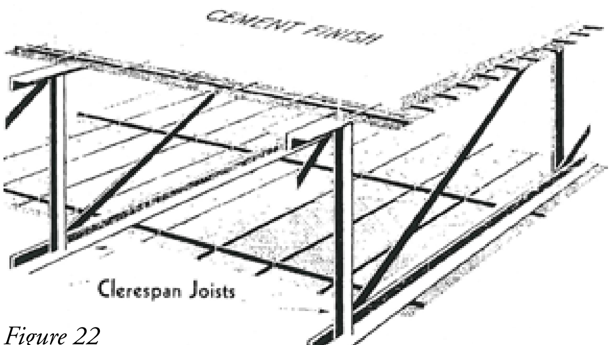
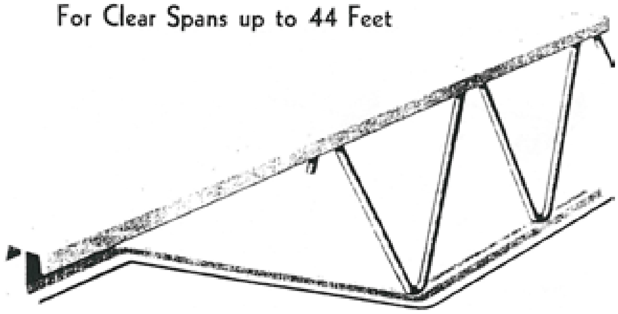


Figure 22

For Clear Spans up to 44 Feet



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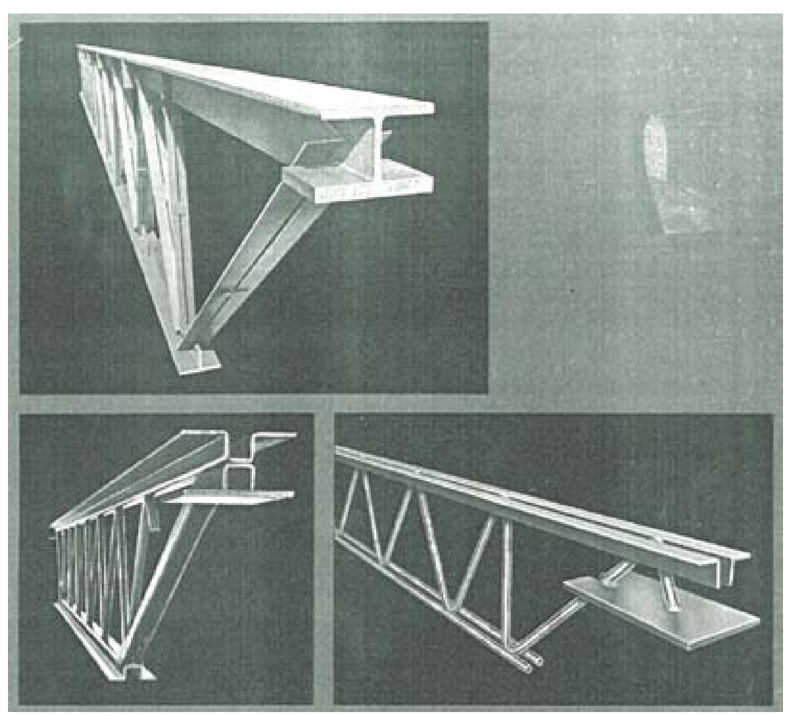

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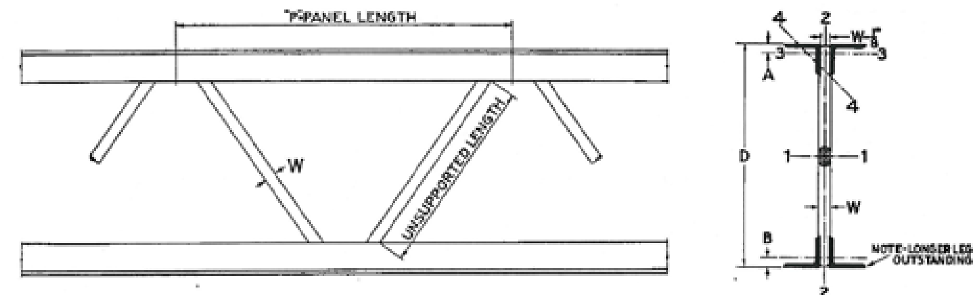

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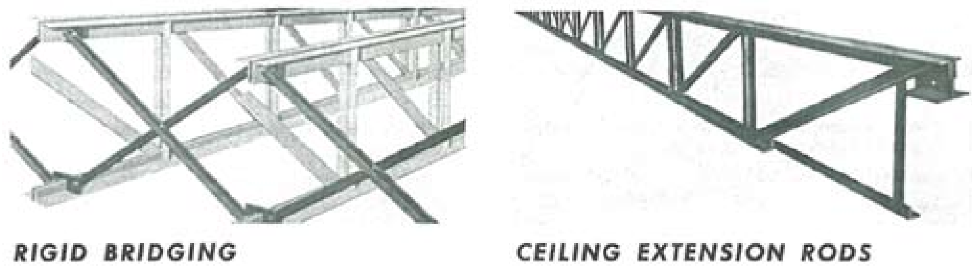

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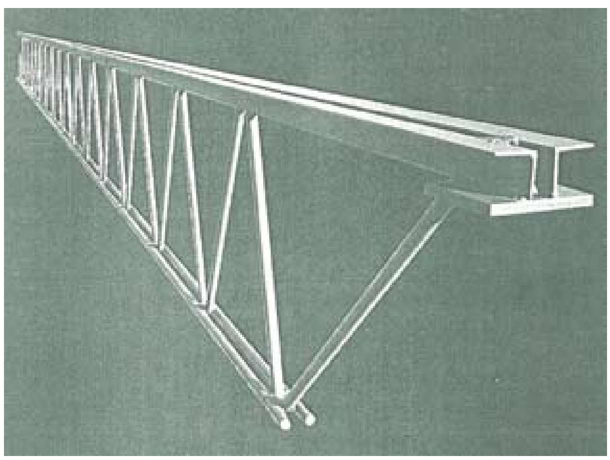

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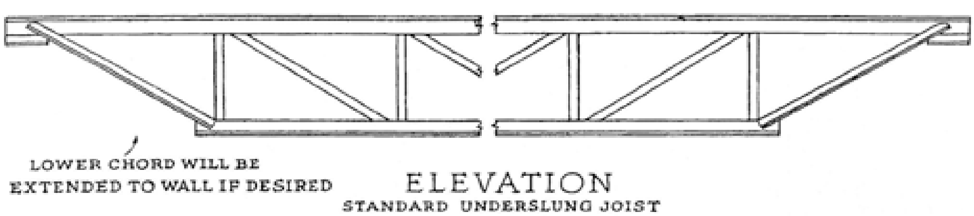

Figure 30