M.I. 9666 *Rev. A

Maintenance Instruction

Technical Publications

ELECTRO-MOTIVE

MODERNIZATION RECOMMENDATION

TURBOCHARGED ENGINE UPGRADE CONVERSIONS

— LOCOMOTIVE ENGINES —

PURPOSE: To upgrade older "E" series 645 model turbocharged engines for higher reliability and increased fuel economy.

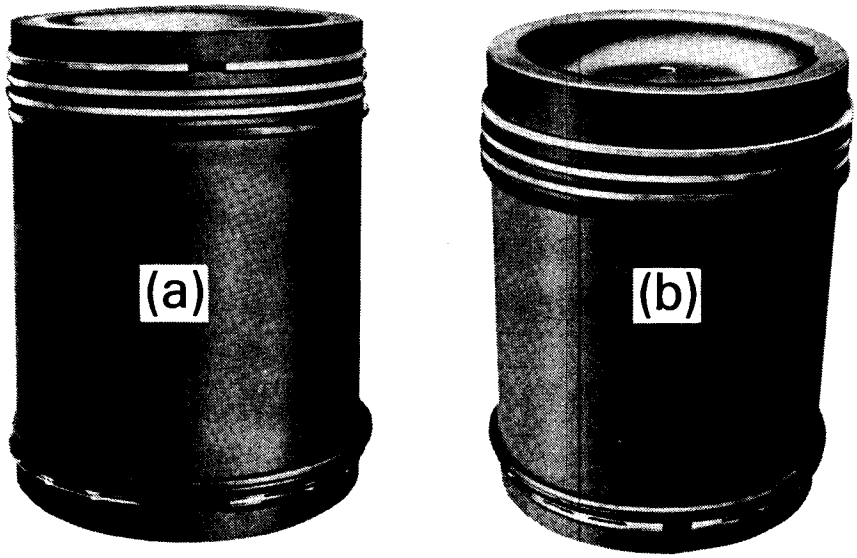
APPLICATION: Engine conversion information presented in this publication applies to "E" series 645 model turbocharged rail engines as listed below.

Conversion	Present	Converted
I.‡	Non fire ring piston EB (i.e., 16-645E3B, 12-645E3B, etc.)	Fire ring piston EB (i.e., 16-645E3B, 12-645E3B, etc.)
II.	E (i.e., 16-645E3, 12-645E3, etc.)	As above
III.	As above	EC (i.e., 16-645E3C, etc.,)
IV.	Non fire ring piston E3B	As above
V.	Fire ring piston E3B	As above

‡ Note that the E3B engine designation alone does not differentiate between non fire ring and fire ring piston application. See Fig. 1.

The fire ring refers to the top compression ring. The ring belt has been moved 1/2 inch closer to the piston crown, thereby increasing the effective length of the power stroke. As a result, the fire ring piston improves engine combustion efficiency and thermal efficiency.

*This bulletin is revised and supersedes previous issues of this number.
Areas of change are indicated by vertical bars.



Non-fire ring and fire ring pistons are distinguished on the outer skirt side by the location of the top piston ring: (a) fire ring piston; 3/4 inch. (b) non fire ring piston; 1-1/4 inch.

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Fig.1 – Piston Comparison

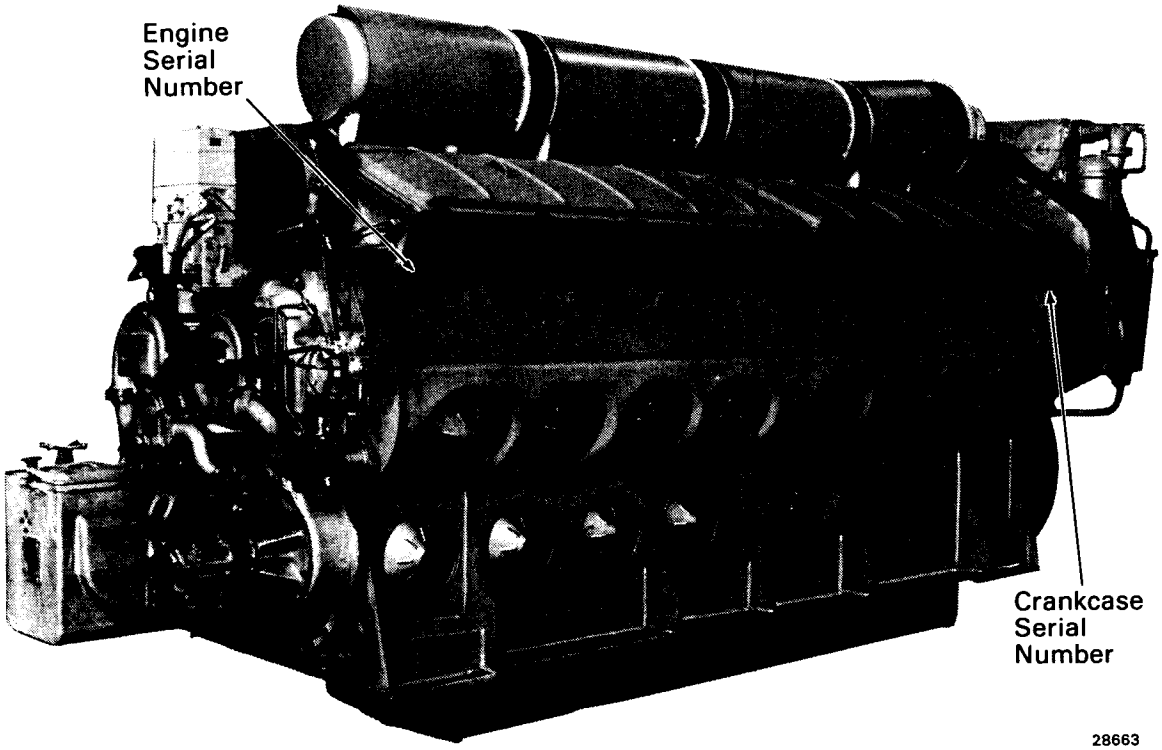

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Fig.2 – Serial Number Locations

REFERENCE: Crankcase serial number considerations or part numbers of components involved in a conversion are identified in the tables listed below. Explanation of footnotes found in Tables D through H is given in Plates I and II.

Table	
A	Crankcase requirement for conversion
B	Governors for fire ring E3B engine conversions
C	Governors for fire ring E3C engine conversions
D	Fire ring EB and EC 8-cylinder engine turbochargers
E	Fire ring EB and EC 12-cylinder engine turbochargers
F	Fire ring EB and EC 16-cylinder engine turbochargers
G	Fire ring EB and EC 20-cylinder engine turbochargers
H	Additional components necessary for conversion
I	Power assembly components

Plate	
I	Explanation of footnotes found in 'turbocharger' Tables D - G.
II	Explanation of footnotes found in 'additional' components Table H.

Conversion I: Conversion I involves only the engine. To effect this conversion replace the 8419089 piston with the 9523619 fire ring piston. A hardened port relief and upper bore liner 9318833 or chrome liner 9090233 must accompany the fire ring piston. See also Table B for the proper governor balanced rack setting.

Conversion II thru V: These conversions involve the turbocharger and engine, including crankcase and governor.

Crankcase:

The crankcase is the main structural member of the engine. Its structural support capability for a given vintage model engine is reflected in the crankcase serial number. Crankcase serial number restrictions for a conversion are identified in Table A. See Fig. 2 for location of crankcase serial number on engine.

Governor:

Governor requirements for a conversion are presented in Tables B and C.

Turbocharger:

Part numbers for turbochargers for E3C and fire ring piston E3B engines are provided in Tables D through G. Footnotes found in those tables are explained in Plate I.

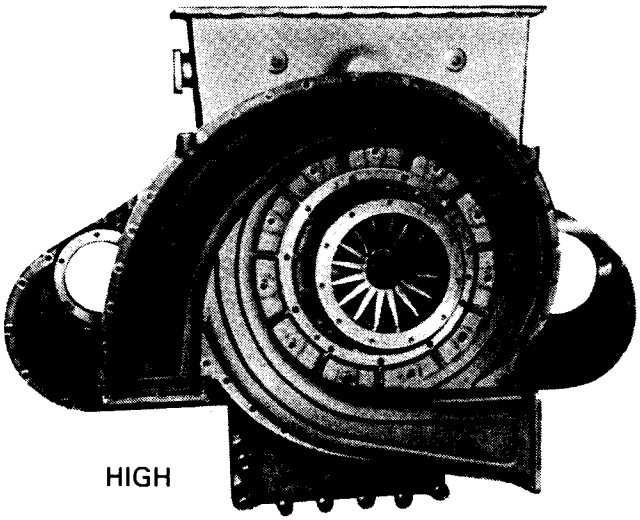
Due to the various engine applications, exhaust duct design, and turbocharger gear train drive ratios, the following are steps to locate the part number for the turbocharger required.

A. Go to the appropriate 8-, 12-, 16- or 20-cylinder engine turbochargers Tables (D,E,F, or G respectively).

B. Go to the line listing the following:

   1. The model of the engine to be converted.

   2. The exhaust duct type (high or low) on the turbocharger on the engine to be converted. See Fig. 3.



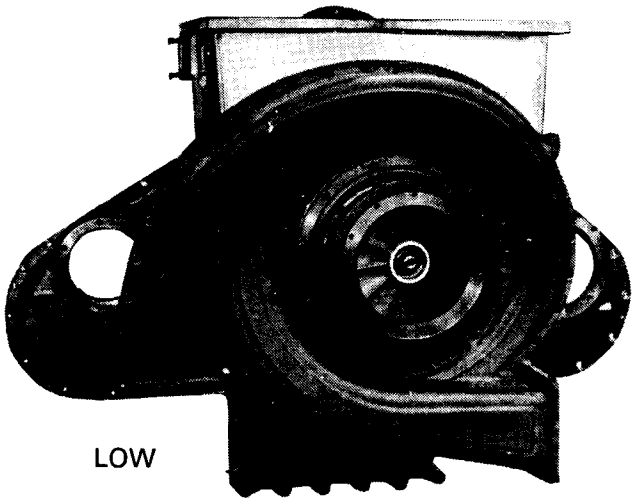


Fig.3 – High And Low Exhaust Duct Turbochargers

3. The gear train drive ratio for the turbocharger on the engine to be converted. This ratio is stamped on the turbocharger nameplate.

4. In the same line, and under the fire ring EB or EC heading (depending on the conversion being made), find the Part Number for the turbochargers to use in the conversion or find an instruction such as "go to line 5" which will lead to a Part Number.

Locomotive Control System Limitations: Locomotive control system limitations exist on pre "-2" locomotives, and also on "-2" models which may preclude application of converted engines unless locomotives are modified as described below.

A. Pre "-2" models require the installation of a "-2" electrical control system, plus a linear load regulator and rate control. Obviously, when completed, this modification results in a "-2" model.

B. Earlier Dash-2 locomotives require the addition of a linear load regulator and rate control.

C. Latest production Dash-2 locomotives incorporating 645EC engine should have the "-2" electrical control system plus a linear regulator and rate control.

TABLE A

CRANKCASE SERIAL NUMBER REQUIREMENT FOR CONVERSION

Engine Model (All Applications)	Crankcase Serial Number To Convert From E Turbo To EB Turbo (Fire Ring)	Crankcase Serial Number To Convert From E Turbo To EC Turbo
8-645 Turbo	Serial Number 76A And Later (January, 1976)	Same As EB With Fire Ring
12-645 Turbo	Serial Number 71D And Later (April, 1971)	Serial Number 72J And Later (September, 1972)
16-645 Turbo	Serial Number 71D And Later (April, 1971) See Note 2	Serial Number 72J And Later (September, 1972)
20-645 Turbo	Serial Number 72J And Later (September, 1972)	Serial Number 82A And Later (January, 1982)

NOTES:

1. Crankcase Serial Number is Located on Left Bank Rear End of the Engine.
2. If the Crankcase Serial Number is Earlier than 71D, the Engine Serial Number must be 73G or Later to insure that the Crankcase has been upgraded.
3. There is No Restriction on reuse of Oil Pan.

TABLE B

GOVERNORS FOR RAIL ENGINE CONVERSION

CONVERSION II - E3 ENGINE TO E3B FIRE RING ENGINE

Loco. Model	Eng. Model	Governor Required		Throttle 8 Rack	Rebal. Press.	Throttle 1 Rack	Engine Speeds		
		New	Utex	In.	In. HGA	In.	Low Idle	Throttle 1	Throttle 8
None	8E3	N.A.	N.A.	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
GP, SD39	12E3	9532792	9535631	0.80	55.5	1.55	235	300	904
GP,SD,SDP-40	16E3	9549687	9549688	0.82	59.0	1.55	255 (*)	318	904
GP,SD,SDP-40	16E3	9549689	9549690	0.82	59.0	1.55	235	300	904
F40PH	16E3	9551457	9551458	0.82	59.0	1.48	255 (*)	390	893
F,FP,SD45	20E3	9512179 [1]	N.A.	0.83	62.0	1.55	255 (*)	318	904

NOTE:
(*) To equip a locomotive unit for 255 RPM low idle speed, see M.I. 9619.

[1] Derated

TABLE C

GOVERNORS FOR RAIL ENGINE CONVERSION

CONVERSION III - E3 OR E3B ENGINE TO E3C ENGINE

Loco. Model	Eng. Model	Governor Required		Throttle 8 Rack	Rebal. Press.	Throttle 1 Rack	Engine Speeds		
		New	Utex	In	In HGA	In	Low Idle	Throttle 1	Throttle 8
None	8E3	N.A.	N.A.	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
None	8E3B	N.A.	N.A.	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
GP,SD39	12E3	9549693	9549694	0.84	56.0	1.55	235	300	904
GP,SD39	12E3B	9546048	9546049	0.84	56.0	1.50	200	269	904
GP,SD,SDP40	16E3	9549691	9549692	0.84	56.0	1.55	255 (*)	318	904
	16E3B	9549693	9549694	0.84	56.0	1.55	235	300	904
		9546048	9546049	0.84	56.0	1.50	200	269	904
F40PH	16E3	9335713	9332870	0.83	57.5	1.48	255 (*)	390	893
	16E3B	9549965	9549966	0.84	56.0	1.48	260	406	916
F,FP,SD45	20E3[1]	N.A.	N.A.	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -
	20E3B		N.A.	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -

NOTE:
(*) To equip a locomotive unit for 255 RPM low idle speed, see M.I. 9619.

[1] Derated

TABLE D

REPLACEMENT TURBOCHARGER

ENGINE CYLINDER CONFIGURATION: 8

Line No.	Engine Model	Exhaust Duct	Gear Ratio	Application	Fire Ring EB		EC
					High Exhaust Duct	Low Exhaust Duct	Low Exhaust Duct
					New/Utex	New/Utex	New/Utex
1	E3	----	----	Rail	9096492/9317665 (1)	9554353/ (4)	9546861/9551898 (4)
2	E3B	High	19.7:1	Rail	As Above		As Above

TABLE E

REPLACEMENT TURBOCHARGER

ENGINE CYLINDER CONFIGURATION: 12

Line No.	Engine Model	Exhaust Duct	Gear Ratio	Application	Fire Ring EB		EC
					High Exhaust Duct	Low Exhaust Duct	Low Exhaust Duct
					New/Utex	New/Utex	New/Utex
1	E3	High	18:1	Rail		9511706/9524135 (4)	9548913/9558255 (4)
2	E3B	Low	18:1	Rail	Not Applicable (3)	As Above	As Above
3	E3B	Low	18:1	Rail	Not Available	9541264/	

TABLE F

REPLACEMENT TURBOCHARGER

ENGINE CYLINDER CONFIGURATION: 16

Line No.	Engine Model	Exhaust Duct	Gear Ratio	Application	Fire Ring EB		EC
					High Exhaust Duct	Low Exhaust Duct	Low Exhaust Duct
					New/Utex	New/Utex	New/Utex
1	E3	High	18:1	Rail	/9525597 (2)	9338194/9339283 (4)	9528223/9543498 (1,4)
2	E3	Low	18:1	Rail	Not Applicable (3)	As Above	As Above
3	E3	Low	16.8:1	Rail - Passenger	Not Applicable (3)	9512453/9524134	9546632/9552711 (4)
4	E3A	High	18:1	Rail	See Line 1	See Line 1	See Line 1
5	E3A	Low	16.8:1	Rail - Passenger	Not Applicable (3)	See Line 3	See Line 3
6	E3B	Low	18:1	Rail	Not Applicable (3)	See Line 1	See Line 1
7	E3B	Low	16.8:1	Rail - Passenger	Not Applicable (3)	See Line 3	See Line 3

Explanation of indices in Tables D through G is presented in Plate I.

TABLE G

REPLACEMENT TURBOCHARGER

ENGINE CYLINDER CONFIGURATION: 20

Line No.	Engine Model	Exhaust Duct	Gear Ratio	Application	Fire Ring EB		EC
					High Exhaust Duct	Low Exhaust Duct	Low Exhaust Duct
					New/Utex	New/Utex	New/Utex
1	E3	High	18:1	Rail	/9525598 (2)	9338196/ (4)	9546635/9553210 (4)
2	E3B	Low	18:1	Rail	Not Applicable (3)	As Above	As Above

Explanation of indices in Table G is presented in Plate I.

TABLE H

ADDITIONAL COMPONENTS NECESSARY FOR CONVERSION

Qty. Pcs. Req. Of Pt. No. Given For Cyl. Config.				Part Number	EB Turbo With Fire Ring	EC Turbo
8	12	16	20		Description Of Part Number	Description Of Part Number
15	23	31	39	9314870(1)	Universal Handhole Cover Asm. w/Handwheel	Universal Handhole Cover Asm. w/Handwheel
1	1	1	1	9314869(1)	Universal Handhole Cover Asm. w/o Handwheel	Universal Handhole Cover Asm. w/o Handwheel
1	1	1	1	9323945	Crankshaft Torsional Gear Damper	Crankshaft Torsional Gear Damper
4	6	8	10	9544257	Conn. Rod - Blade (SAE 4140)	Conn. Rod - Blade (SAE 4140)
4	6	8	10	8159138(2)	Conn. Rod - Blade (SAE 1046)	Conn. Rod - Blade (SAE 1046)
8	12	16	20	9581924	Aluminum Bronze Cylinder Head Seat Ring - w/Viton Seal	Aluminum Bronze Cylinder Head Seat Ring - w/Viton Seal
16	24	32	40	9317972	Water Outlet Seal Rings	Water Outlet Seal Ring
8	12	16	20	8228554	Liner Air Seal-Up Groove	Liner Air Seal-Up Groove
8	12	16	20	9316850	Liner Air Seal-Low Groove	Liner Air Seal-Low Groove
8	-	-	20	5229320	Fuel Inj. (UTEX 8478053)	Fuel Inj. (UTEX 8478053)
-	12	16	-	5229335	Fuel Inj. (UTEX 8478055)	Fuel Inj. (UTEX 8478055)
24	36	48	60	9319503	Cam Follower Crown Roller	Cam Follower Crown Roller
24	36	48	60	8135970(3)	Cam Follower Inner Race	Cam Follower Inner Race
24	36	48	60	8135971(3)	Cam Follower Bushing	Cam Follower Bushing
8	12	16	20	9527320(4)	EB Fire Ring Power Asm. - Less Rod	
8	12	16	20	9550599(4)		EC Power Asm. - Less Rod
-	-	-	2	(5)	Camshaft Segment 8361803	8433618 Camshaft Segment
-	-	-	2	(5)	Camshaft Segment 8361012	8433602 Camshaft Segment
2	-	4	-	(5)	Camshaft Segment 8261194	8419849 Camshaft Segment
-	2	-	-	(5)	Camshaft Segment 8261442	9318994 Camshaft Segment
-	2	-	-	(5)	Camshaft Segment 8261443	9318995 Camshaft Segment
20	28	40	48	9085894(6)	Necked Down Crab Bolt	Necked Down Crab Bolt
20	28	40	48	8040808(6)	1-3/4" - 12 Hex Nut	1-3/4" - 12 Hex Nut
20	28	40	48	9319172(6)	Washer	Washer
6	8	12	16	9319170(6)	Intermediate Crab Plate	Intermediate Crab Plate
4	4	8	8	9523067(6)	End Crab Plate	End Crab Plate
-	2	-	-	9332871(6)	Center Crab Plate	Center Crab Plate

Explanation of indices in Table H is presented in Plate II.

TABLE I

POWER ASSEMBLY COMPONENTS (MINUS ROD)

1	9318833	Cyl. Liner Stud Asm.
1	9319736	Cyl. Hd. Sub. Asm.
1	8442120	Carrier Piston
1	8442226	Bearing, Insert
1	9518958	Pin, Piston*
2	9548905	Retainer, Bearing
2	9536664	Clip, Locking
2	9547667	Bolt Asm.
1	8135330	Washer, Thrust
2	8159340	Bolt Asm.
1	8442936	Gasket**
12	8384771	Insulator, Seal
12	8384772	Seal, Water
1	9516928	Ring Set, Piston
1	9338809	Piston Ring, Compression
2	8418589	Piston Ring, Compression
1	8347100	Piston Ring, Compression
1	8347103	Piston Ring, Oil Control
1	8464953	Piston Ring, Oil Control
8	8060089	Nut, 3/4"-16 Self Locking
8	8140912	Washer, Special

The above plus –

9523619 piston (14.5:1 fire ring) compose the 9527320 EB assembly with fire ring piston.

9564583 piston (16:1) with gasket 8442936 (**) compose the 9550599 EC assembly.

*Piston pin 8417645 may be used provided it is dated 80D or later.

PLATE I

NOTES RELATING TO TURBOCHARGER TABLES

1. Following an EB turbocharger consolidation, the EB turbocharger features a convertible idler gear support to allow field modifications to a left or right hand rotation engine. Utex turbocharger must therefore be modified to provide this convertibility.

2. No new part number exists for this configuration. The utex part number represents a remanufactured turbocharger which matches the design criteria for a new machine while retaining the original installation envelope.

3. This configuration will not fit the existing installation.

4. The E3B turbocharger is equipped with a revised exhaust duct which is two inches shorter at the exhaust stack flange to provide low profile exhaust silencer mounting. When applied to a locomotive originally equipped with an E3 turbocharger, the exhaust stack will, therefore, be two inches shorter relative to collar assembly 8353598. This is not expected to create any problems, since the stack originally protruded nominally 1-11/16" above the top of the collar assembly. If the carbody to engine height tolerance results in the top of the stack with an E3B turbocharger being more than 3/4" below the top of the collar, four strips of 11 ga. steel 2" wide could be welded around the inside of the collar assembly to extend the inside lip of the collar to overlap the stack.

   For new locomotive production with E3B engines from July through December, 1979, the exhaust stack was not changed, but rather a shorter collar assembly, 9516358 was used. Starting January 1, 1980 all units will have exhaust silencers and a new turbo hatch.

PLATE II

NOTES RELATING TO TABLE H

1. EMD has adopted universal handhole covers 9314870 (w/handwheel) and 9314869 (w/o handwheel) as standard for turbo engines (E3, E3B, E3C). Each cover requires gasket 8291349. These high strength covers utilize a heavy duty crossbar which is straddled by a U-shaped bracket, instead of a locating pin arrangement. The high strength cover is identified by two 1-1/4" diameter embossments on the cover face.

2. The 8159138 connecting blade rod may be used in an E3B engine, provided the serial number on the rod is 80E or later or the rod is stamped "E3B" or "GP50". If not, 9544257 must be used.

3. The cam follower inner race 8135970 as well as the cam follower bushing 8135971 should be replaced in a conversion.

4. See Table I.

5. If qualified the camshaft segment may be used in the conversion, otherwise use EC engine camshaft segment part number as listed.

6. The 8, 12 and 16 cylinder E3B engines now incorporate as basic the cylinder head plate crab retention system. The change was made to improve the torque retention capability and to standardize the E3B engines with the current production E3C engine components. The plate crab will require necked down crab bolt 9085894, a 1-3/4"-12 hex nut 8040808, and washer 9319172. To apply the accessory end plate crab, minor work may be required for proper seating of the crab. 1/8" may have to be removed from the top deck head frame as shown in Fig. 4.

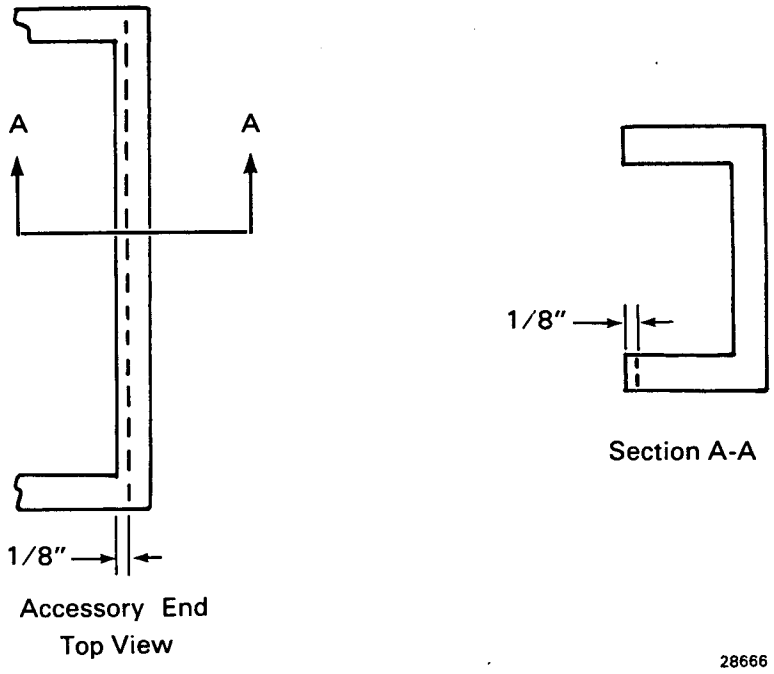


Fig.4 - Head Frame Modification