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of Transportation
**Urban Mass
Transportation
Administration**

Air Conditioning Modifications to AMG Buses

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16. Abstract

This report presents the documentation and evaluation of air conditioning system modifications devised by Miami (FL) Metrobus and Los Angeles SCRTD for the AM General Model B bus. The objective of these modifications was to reduce the frequency of bus air conditioning and related system failures. Major modifications included both relocation of, and replacement and relocation of, the A/C condenser, installation of new condenser fans and an additional alternator, and replacement of certain other air conditioning system components.

The documentation of the air conditioning modifications discusses the extent of air conditioning related problems encountered in the operation of AMG buses and lists the agencies' goals and objectives in devising solutions to these problems. Narrative descriptions along with photographs, parts lists, procedures and costs for the modifications are given, with sufficient detail to permit other transit authorities having similar problems to implement these changes to their coaches should they desire to do so.

The evaluation of the air conditioning modifications focuses primarily on system reliability. Data for the evaluation was extracted from existing maintenance and other records at Metrobus and SCRTD. These included road call reports, daily service reports and bus repair history records.

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PREFACE

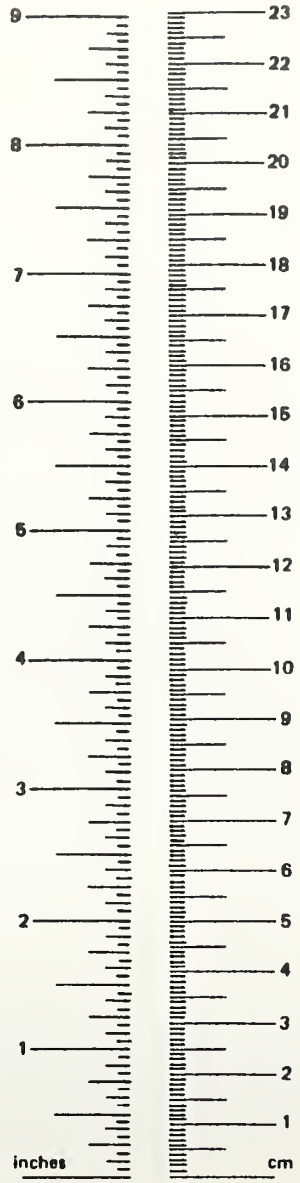
The Transportation Systems Center wishes to acknowledge the fine spirit of cooperation extended by the personnel both at Miami's Metropolitan Dade County Transit Agency (Metrobus) and at Los Angeles' Southern California Rapid Transit District (SCRTD). Compilation of this document would not have been possible without their efforts. Special thanks are extended to Joseph Dooley, Director of Operations and Charles George and his staff of maintenance personnel, including Alfred Powell and Israel Porras, at Metrobus. At SCRTD, we are indebted to Frank Kirshner, Director of Equipment Engineering and his staff, including Michael Bottone and Russell Petersen, as well as to Bob Falvey, Ted Desy and the other personnel at the Central Maintenance Facility.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

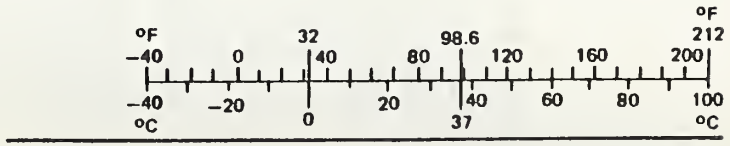
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimetere	cm
yd	yerds	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	squere inches	6.5	square centimeters	cm^2
ft^2	squere feet	0.09	square meters	m^2
yd^2	squere yards	0.8	square meters	m^2
mi^2	squere miles	2.6	squere kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grems	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	teblespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	querts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yerds	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fehrenheit temperature	5/9 (efter subtracting 32)	Celsius temperature	°C

*1 In. = 2.54 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286, Units of Weight and Measures. Price $2.25 SD Catalog No. C13 10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yerds	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	squere centimeters	0.16	squere inches	in^2
m^2	squere meters	1.2	square yards	yd^2
km^2	squere kilometers	0.4	squere miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grems	0.035	ounces	oz
kg	kilogrems	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fehrenheit temperature	°F



EXECUTIVE SUMMARY

Air conditioning and ventilation system problems are some of the most urgent problems of the transit operator in terms of general fleet reliability, maintainability, and efficiency. In an effort to improve the air conditioning system, a number of transit agencies have made modifications to some of their coaches. Two of these agencies, the Southern California Rapid Transit District (SCRTD) at Los Angeles and the Metropolitan Dade County Transit Agency (Metrobus) at Miami, have devised, implemented and tested modifications for their AM General Model B buses. The primary objective of these modifications was to reduce the downtime of these coaches caused by air conditioning system related failures.

As part of its bus and paratransit technology research and development efforts, the Urban Mass Transportation Administration (UMTA) is conducting the Bus Subsystems Technology Project to help the transit bus industry solve serious equipment problems. The principal objective of this project is to reduce the recurring costs necessary to operate the U.S. transit bus fleet by developing improved subsystem technologies that can be adopted by operators and manufacturers in the near future. An important element of the program is to foster communication among, and disseminate information to, the transit community on progress and results of bus technology projects. Consequently, UMTA's Office of Bus and Paratransit Systems sponsored the Department of Transportation's Transportation Systems Center (TSC) to undertake a project to document and evaluate the Metrobus and SCRTD air conditioning modifications.

The objectives of the project were twofold. First, the modifications were to be sufficiently documented so that other transit properties, if they so choose, could implement the same changes to their coaches and indeed, many operators have expressed interest in learning the details of the Miami and Los Angeles air conditioning modifications. The importance of such information is emphasized by the fact that many AMG-Model B coaches are in operation but the model is no longer manufactured and the AM General organization is no longer in the bus business. Secondly, the modifications were to be evaluated to determine their impact on both component reliability and fuel economy.

The required information was obtained from Metrobus and SCRTD through field visits to Miami and Los Angeles for extensive discussions with agency personnel, review of the implementation of the air conditioning modifications, review of available drawings/sketches, and detailed examination of bus maintenance records. The data/information thus obtained was the foundation for developing the documentation material and evaluating the modifications. No data were collected beyond what was available at the transit property. The developed documentation materials were reviewed thoroughly with both Metrobus and SCRTD personnel.

Miami purchased 140 AMG 9640B buses in 1976, all of which, according to Metrobus, have experienced an unusually high number of breakdowns related to the air conditioning system. The most significant factor influencing their modification design was the decision to relocate the O.E.M. A/C condenser. This modification required removing the condenser from its original position and placing it in the back of the bus in the rear window area. However, this location, plus the size and shape of the condenser, left no room for intake air louvers, or the condenser fan, in the window area. Therefore, an opening was cut into the roof of the bus for intake of condenser cooling air and new ductwork was fabricated to provide a path for this airstream and for housing the fan and motor assembly.

In 1977-78, Los Angeles purchased 200 AMG 10240B buses, most of which have experienced breakdowns similar to those in Miami. These buses are equipped with a roof hatch in the same general area that would be required for the [Metrobus-design] cooling air intake opening. This fact, plus the shape of the oversized O.E.M. condenser, prompted SCRTD to reject using this unit in their modification. Instead, the agency took advantage of the opportunity to utilize good used parts available from some of the retired buses inevitably found in a fleet as large as Los Angeles'. The condenser from a Flxible, New-Look" bus was incorporated in the SCRTD modification and installed, with two additional cooling fans, in the rear window area of the bus.

These air conditioning modifications are documented by this report, which includes a detailed narrative, photographs, parts lists, and a description of the necessary procedures.

With the limited amount of information collected to date, the evaluation of the air conditioning modifications concludes that:

- The Miami and Los Angeles air conditioning modifications substantially reduced road calls.

- Based on an analysis of the various aspects of the air conditioning modifications, the changes made at Miami and Los Angeles could result in some improvement in coach fuel economy. However, it was not possible to confirm this with the available data.

TABLE OF CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

AM General Model (B) transit buses, now in revenue service, have experienced a number of operational problems since they were introduced in 1975. Many of these problems are traceable to several design deficiencies. In particular, the air conditioning system has been responsible for a significant portion of unscheduled maintenance actions on these coaches. This report describes how two large transit agencies have approached the problem of modifying their buses to circumvent difficulties with the air conditioning system and is presented so that other transit agencies may be helped by their experience.

In general, most of the AMG air conditioning problems are traceable to condenser cooling problems (and ramifications thereof) inherent in the original design, as well as to certain design faults in the air conditioning compressor mounting and belt tensioning mechanisms. As manufactured, the A/C condenser was located back-to-back with the engine radiator so that they both could dissipate their heat to the same air stream. The design incorporated a fan system capable of higher-than-normal air flow rates to meet the double cooling requirements of this arrangement.

When the buses are on the street, this increased air velocity causes a stirring-up of greater quantities of dirt and debris than occurs with buses having a "normal" air flow rate. Because of the specific related locations of the radiator and condenser, certain areas, such as their inner faces, are inaccessible for easy cleaning. The disturbed dirt and debris tend to be carried to, and collect there resulting in a serious deterioration of the heat dissipation capacities of both units.

In addition, the air is picked up near street surface level where it tends to be hotter than the ambient air. Air flowing into and through the engine compartment is thus often very hot. Air temperatures near the face of the condenser can be as high as $180^{o}F$. In the engine compartment, air temperatures as high as $300^{o}F$ have been measured near the transmission and air conditioning compressor.

Under these conditions, overheating can easily occur and cause a range of bus mechanical problems affecting reliability and component life.

Among these are degraded performance, and failure, of A/C compressors, bus engines, transmissions, starters, and other system components. For example, a pressure in excess of 500 psi (vs. a normal range of 250-400 psi) is required to condense the refrigerant at a 300^{o} condenser inlet temperature and pressures in that range adversely affect A/C component reliabilities. Unsatisfactory A/C compressor mounting and belt tensioning mechanisms have also contributed to the poor service record of these buses.

In addition, when breakdowns do occur, passengers are inconvenienced, revenue service time is lost, and maintenance costs increase. Also, regularly scheduled maintenance operations are affected and often crippled as a result of the repair demands generated by the deficient AM General air conditioning design.

Table 1 summarizes the air conditioning problems encountered with AMG Model B buses.

TABLE 1

AMG MODEL B BUS
AIR CONDITIONING SYSTEM
PROBLEM AREAS

Design Deficiencies

- Faulty air conditioning condenser location
- Faulty A/C compressor mounting
- Faulty belt tension device

Failures Associated with Deficient Design

- A/C compressor failure due to abnormally high head pressure and temperatures
- Short engine life due to hot engines
- Extremely low transmission life due to hot transmission operation
- Premature starter failure due to no starts (tight engine from overheat)

Resulting Impacts

- Many "in-service" breakdowns
- Excessive road calls
- High repair costs
- High coach downtime
- Lost revenue
- High inconvenience to the public

TABLE 2

Comparison of Miami Metrobus Road Call
Frequency for AMG Buses vs. Total Fleet
(July, August, September, 1982)

	Total Fleet	AMG Fleet
Number of Coaches	610	131
Miles Run	6.15×10^6	1.02×10^6
Mechanical Road Calls	6311	1809
Mean Miles Between Road Calls	974	563

Table 2 gives an indication of the extent of the problem at Miami. The figures show that while the AMG buses comprise 21.5% of the total Metrobus fleet, they accounted for only 16.5% of the fleet mileage but were responsible for almost 29% of all mechanical road calls during the period. Thus, it can be seen that the AMG buses account for a disproportionately high number of road calls, 65% of which, the Maintenance Department estimates, were A/C related.

2.0 OBJECTIVE

As part of its bus and paratransit technology efforts, the U.S. Department of Transportation's Urban Mass Transportation Administration (UMTA) has a responsibility to assist the transit industry in dealing with serious problems in bus system and subsystem hardware. The objective of this work is to reduce the costs associated with the operation of urban transit buses through the development of more reliable and efficient mechanical and electrical system components.

One method of aiding the transit industry is this endeavor is to publish information on methodology developed, and results achieved, in any successful attempt to increase component operating life, fuel economy, and/or efficiency. Publication of such information in detailed form will thus enable members of the transit industry to utilize the developed technology to achieve similar results.

In an effort to assist other transit properties having problems with the air conditioning in AMG Model B coaches, the Department of Transportation's Transportation Systems Center (TSC), under the sponsorship of UMTA's Office of Bus and Paratransit Systems, has undertaken such a documentation effort. In this project, the methods and procedures used for, and the results obtained from, air conditioning system modification work done on AMG buses, were observed and recorded.

This report describes how the modification efforts were carried out by the Metropolitan Dade County Transit Agency (Metrobus) of Miami, Florida, and the Southern California Rapid Transit District (SCRTD) of Los Angeles, California. The Miami Metropolitan Dade County area covers approximately 2081 square miles and contains more than one and a half million people whose only form of public transportation is the Metrobus fleet of 610 coaches. Metrobus originally purchased 140 AMG Model B buses - all equipped with air conditioning - of which 131 are still in service. Air conditioning is used 12 months of the year.

Tne Southern California Rapid Transit District area covers approximately 2280 square miles in all of Los Angeles County and in areas of San Bernardino, Orange, Riverside and Ventura counties. Approximately 9 million people live/work in the area covered. SCRTD purchased 200 air conditioned AMG Model B buses, all of which are still in service. Air conditioning is used 12 months of the year here also.

3.0 APPROACH

Visits to both Miami and Los Angeles were made by TSC personnel to coincide with the installation of their respective air conditioning modifications in AM General buses. Photographs of each step were taken during the installation and procedures were determined and documented as they occurred. Management and technical staff meetings were attended. Each phase of the modification required a different shop discipline and consequently discussions were held with the supervisor and maintenance personnel of such departments as their work progressed. Existing maintenance records were surveyed to compile pertinent data. Follow-up telephone calls were made after the site visits to clarify data or request additional information. Subsequently, discussions were held to review and refine the material.

This documentation effort took place during early 1983. The first bus to be modified at Miami was finished in January of 1980 while their remaining test buses were completed in the fall of 1982. At Los Angeles, all test buses were modified during the last half of 1982.

4.0 TRANSIT AGENCY MODIFICATION OBJECTIVES

The objectives of the Miami and Los Angeles transit agencies' modifications were to correct the deficiencies in coach air conditioning performance and reliability which stemmed from inadequate cooling capability of the refrigerant condenser. The primary goal was to reduce the frequency of failures of the air conditioning system resulting from high operating temperatures and the associated high compressor discharge pressures. Secondary goals were to reduce the frequency of other component failures, to increase fuel economy, and to reduce operating costs. The air conditioning modifications were devised with the following additional considerations in mind:

- To be retrofittable with minimal complexity to all AMG Model B coaches, using as many AMG parts as possible.
- To minimize costs for parts, materials and labor.
- To increase total coach weight minimally, if at all.
- To alleviate the problem of engine and transmission failures by decreasing operating temperatures

5.0 DESCRIPTION OF AIR CONDITIONING MODIFICATIONS

The two different condenser relocation design concepts, initially developed by Miami Metrobus and Los Angeles SCRTD have been implemented and installed in revenue service buses. Because of revisions and refinements to the original installations, five variations now exist.

This section introduces and highlights each modification as it was developed. This approach is consistent with the procedures contained in the appendices which provide more detailed information. The different modifications are identified and referred to as Miami Mod. #1, Miami Mod. (Final) and L.A. Mod. #1, L.A. Mod. #2, and L.A. Mod. (Final). Changes to the bus body are referred to in the context of "body skin", "body sheet metal" or "body structural", whichever simplifies and best contributes to the understanding of the text. "Mechanical" modifications signify modifications to the refrigeration components and related hardware.

5.1 Miami Air Conditioning Modifications

5.1.1 General - Miami's structural A/C modifications consisted of removing the rear window, inside rear wall and rear panel, and then cutting or detaching elements of the body skin, roof, hand rails, light fixtures and roof bow. The O.E.M. condenser was moved to the upper rear section of the bus behind an aluminum grill (Figure 1).

5.1.2 Mod. #1 - Miami mounted the condenser on a hinge to allow it to swing out for cleaning. A sheet metal duct, which houses the single condenser fan, was installed directly behind the condenser and protective grill. Intake air is drawn into the duct from an opening cut in the roof of the bus (Figure 2) and then forced through the condenser. The interior rear wall of the bus was replaced with sheet metal and covered with rugging to provide a finished look (Figure 3).

FIG. 1. MIAMI MOD. #1
RELOCATED O.E.M. CONDENSER

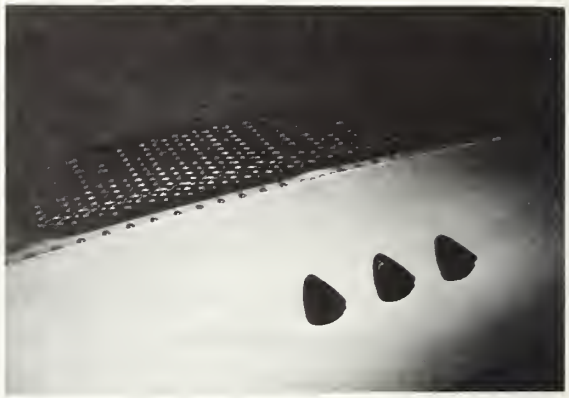


FIG. 2. MIAMI MOD. #1 & (FINAL)
AIR INTAKE AT ROOF OF BUS

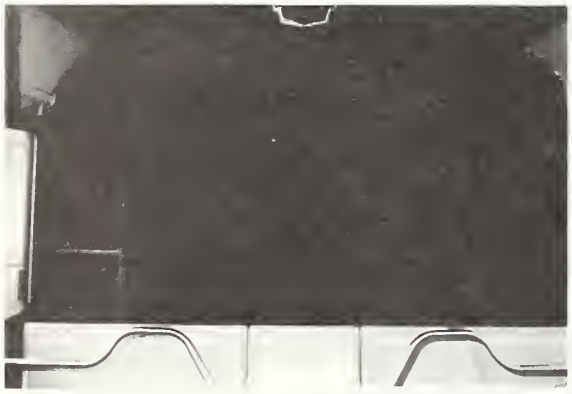


FIG. 3. MIAMI MOD. #1 SHEETMETAL,
RUG-COVERED INSIDE REAR WALL

FIG. 4. MIAMI MOD. #1 & (FINAL)
RTS MOUNTING BASE COMPONENTS

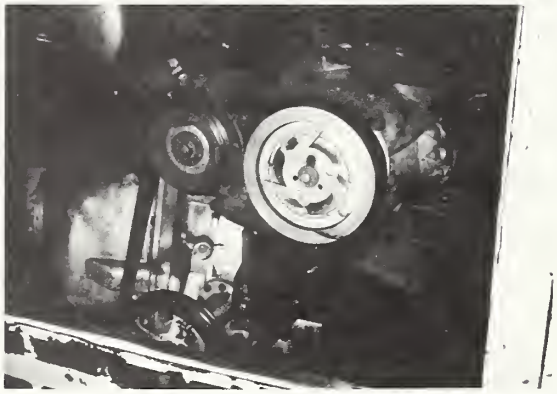


FIG. 5. MIAMI MOD. #1
ALTERNATOR AND COMPRESSOR ON RTS BASE

Miami Mod. #1 mechanical air conditioning modifications consisted primarily of discarding the original compressor mounting base and the belt tensioning cylinder. The O.E.M. Trane compressor was mounted on a new (RTS) base (Figure 4) which was bolted to the V730 transmission housing. The base also provided a belt tensioning pivot mounting location for the additional alternator required to power the condenser fan (Figure 5).

When the O.E.M. condenser was removed from in front of the engine radiator, the open space left was bridged with a shroud to prevent road debris from entering and blocking the air flow to the radiator.

5.1.3 Mod. (Final) - This A/C modification was a refinement of Mod. #1 and used molded fiberglass ducts (Figure 6), interior partition (Figure 7) and exterior enclosure paneling (Figure 8) of their own manufacture in place of the sheet metal components used in Mod. #1.

The condenser fan and motor are still located inside the lower section of the intake air duct shroud (square section) (Figure 6). The interior partition (Figure 7) has a service access door which is in line with the access door (Figure 6) in the intake air duct housing the condenser fan and motor.

Miami's Mod. (Final) requires the same body changes as for Mod. #1. The original condenser is located in the same position as in Mod. #1, but a louvered panel (Figure 8) was used in place of the Mod. #1 aluminum grill (Figure 1). However, a major refinement is that the condenser is bolted and fixed in place. The swing-out condenser design employed in Mod #1 for cleaning purposes proved to be unnecessary because the new location of the condenser provides, essentially, for self-cleaning by the flow of rain water. Also, since the intake air duct opening is at the roof level of the bus, intake air is cleaner than in the original design and the condenser, therefore, requires less cleaning.

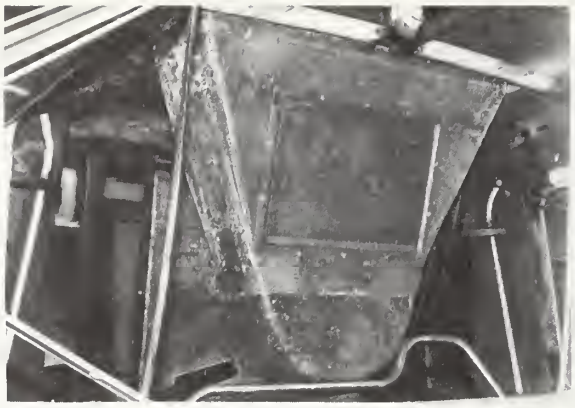


FIG. 6. MIAMI MOD. (FINAL)
FIBERGLASS INTAKE AIR DUCT AND FAN SHROUD

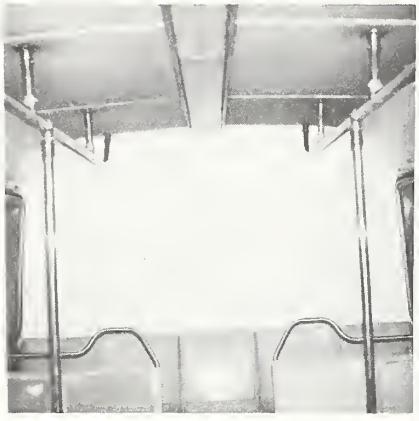


FIG. 7. MIAMI MOD. (FINAL)
FIBERGLASS INTERIOR PARTITION

FIG. 8. MIAMI MOD. (FINAL)
FIBERGLASS LOUVER PANEL

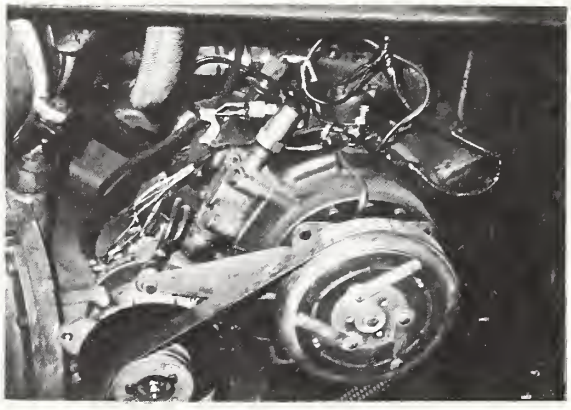


FIG. 9. MIAMI MOD. (FINAL)
MOUNTED CARRIER COMPRESSOR ASSEMBLY

The mechanical changes in Miami's Mod. (Final) consisted basically of discarding the original Trane compressor, mounting base, the belt tensioning cylinder, the "HI-LO" pressure switch, voltage regulator and belts. The compressor used in the Miami Mod. (Final) is a six cylinder Carrier mounted on an RTS base with the additional alternator for the condenser fan (Figure 9). A V-Band belt, matched to a three groove pulley, is used to drive the alternator and compressor. Miniature high and low pressure switches are installed directly on the compressor (Figure 9).

A new voltage regulator, relay and resistor (Figure 9) are used in accordance with modified A/C wiring. Prior to receiving the replacement compressors, the Trane compressors were used in Mod. (Final) with the same control hardware. More specific details on Miami's modifications are given in Appendix A.

5.2 Los Angeles Air Conditioning Modifications

5.2.1 General - L.A.'s structural A/C modification consisted of removing the rear window, inside wall and rear panel, and then cutting the body skin. The original condenser was replaced with a Flxible "New-Look" condenser located on the rear window shelf panel above the engine compartment (Figure 10). The "New-Look" condenser is located in the rear of the bus for all modification designs as shown in Figure 10. However, the mounting orientation of the two condenser fans and motors relative to the condenser face is different for each of the modifications.

5.2.2 Mod. #1 - L.A. used the "New-Look" condenser with two 14" diameter condenser fans and motors mounted horizontally and in line with the face of the condenser (Figure 11). Intake air is drawn through louvers located in the body skin above the condenser. The condenser is protected with a removeable, expanded-aluminum grill (Figure 12). The interior rear wall was framed with wood and angle iron and covered with white melamine plastic laminate (Figure 13). A shroud, similar to that installed in the Miami modifications, was placed in front of the radiator.

FIG. 10. L.A. MOD. #1, #2, & (FINAL) FLXIBLE "NEW-LOOK" CONDENSER

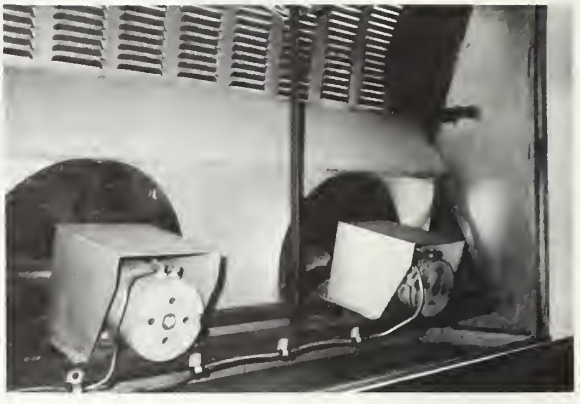


FIG. 11. L.A. MOD. #1 FANS MOUNTED HORIZONTALLY IN-LINE WITH CONDENSER

FIG. 12. L.A. MOD. #1 AIR INTAKE LOUVERS IN BODY SKIN

FIG. 13. L.A. MOD. #1 WHITE PLASTIC LAMINATE INTERIOR REAR PARTITION

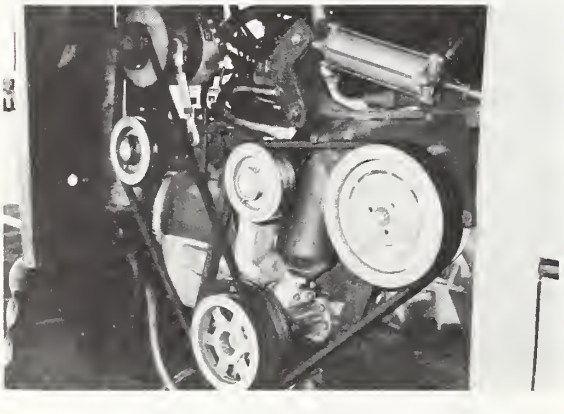


FIG. 14. L.A. MOD. #1 MECHANICAL A/C MODIFICATION

L.A. Mod. #1 mechanical A/C modifications were relatively minor and consisted of stiffening the original bulkhead compressor mounting base, installing the additional condenser fan alternator and mounting plate, rebuilding the belt tensioning cylinder, installing an idler pulley and attaching a drive pulley to the power take-off pulley (Figure 14). The O.E.M. compressor and controls were retained.

5.2.3 Mod. #2 - Structural A/C modifications to the body skin were similar to those of Mod. #1, the size and number of air intake louvers being changed slightly. The "New-Look" condenser was used and installed in the same location as in Mod. #1. A major change was the two 14" diameter condenser fans and motors being oriented 90° from the condenser face in a vertical position (Figure 15) to permit a better air flow pattern through the condenser. The interior rear partition was framed with wood and angle iron and covered with wood-grain melamine plastic laminate (Figure 16). This change from the white plastic in Mod. #1 was to discourage use of the partition as a writing surface and to minimize light reflections to the driver.

The Mod. #2 mechanical changes were the same as those of Mod. #1.

5.2.4 Mod. (Final) - Structural A/C design for this modification, as in Mods. #1 and #2, consisted of removing the rear window, rear panel, and inside rear partition and then cutting the body sheet-metal skin. In Mod. #1 and #2, this sheet metal was retained for air intake louvers which became part of the bus body (Figure 12). Mod. (Final) departed from this approach, a clearance opening being cut (Figure 17) to receive a pre-assembled plenum chamber (Figure 18) which houses the "New Look" condenser, two 18" diameter fans, fan shroud and fan motors. This welded, watertight, steel assembly was designed and built by SCRTD shops and was welded into place in the finished opening in the back of the bus (Figure 19).

A hinged access panel, louvered for air intake, is attached to the skin of the bus above the condenser fans. A removable, expanded-aluminum grill is used in front of the condenser for protection and to allow air flow (Figure 20). The interior rear partition received the same treatment as in Mod. #2.

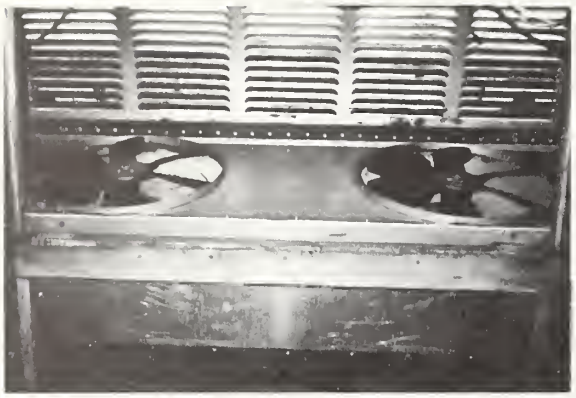


FIG. 15. L.A. MOD. #2 FANS MOUNTED VERTICALLY PERPENDICULAR TO CONDENSER

FIG. 16. L.A. MOD. #2 WOOD-GRAIN PLASTIC LAMINATE INTERIOR REAR PARTITION

FIG. 17. L.A. MOD. (FINAL) FINISHED OPENING FOR A/C ASSEMBLY

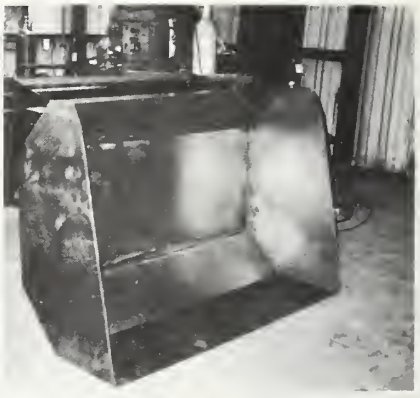


FIG. 18. L.A. MOD. (FINAL) A/C PLENUM CHAMBER

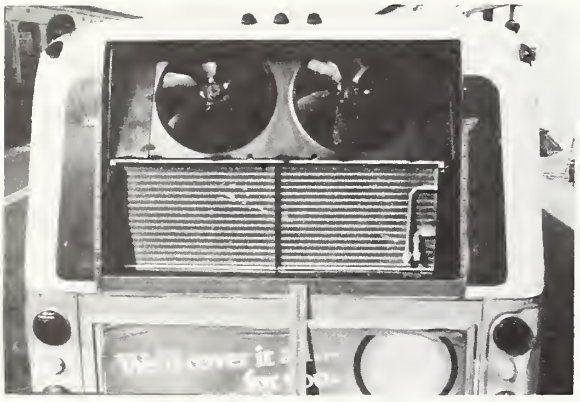


FIG. 19. L.A. MOD. (FINAL) A/C ASSEMBLY IN LOCATION

FIG. 20. L.A. MOD. (FINAL) LOUVERED INTAKE GRILL IN FRONT OF CONDENSER FANS (PRIME PAINTED)

The engine compartment access door was modified by cutting two openings for better air circulation (Figure 21) to assist in reducing engine compartment temperatures.

L.A.'s Mod. (Final) mechanical changes did not reuse the O.E.M. compressor mounting base, air tensioning cylinder or compressor/clutch assembly. A four-cylinder Thermo-King compressor/clutch package (Figure 22) was used and mounted on a newly designed compressor base (Figure 23) which bolted to the side and rear housing of the V730 transmission. A shelf on the base was provided for mounting the additional alternator, a new alternator locking bracket was used and a new drive pulley was attached to the power take-off (PTO) pulley (Figure 22). The transmission oil filter was relocated to the bulkhead to provide space for this modification. The controls are basically as supplied by the O.E.M. except for the added alternator relay and minor wiring changes. More specific details on Los Angeles' modifications are given in Appendix B.

5.3 Additional Miscellaneous Modifications by Miami and Los Angeles

5.3.1 Miscellaneous Modifications by Miami Metrobus

Miami experienced a problem with shearing of the engine cooling fan drive mounting studs, which resulted in the fan penetrating the radiator. It was determined that the combination of the heavy (28 pound) metal fan and abrupt stopping of an overheated engine stressed the studs sufficiently to fatigue and eventually shear them. A lightweight, molded, one-piece fiberglass fan is now being used which, so far, has eliminated this problem.

The two speed evaporator blower motors were replaced with single speed motors. Problems had been experienced with the original blower motors, such as short motor life and frequent brush replacements. The replacement motors are equipped with larger brushes which provide longer life, and are designed to allow servicing of the brushes without removing the entire motor from the coach. The new motors fit the original mounting assemblies and although they deliver more air than required when in the heating mode, this increased air flow has presented no problems.

FIG. 21. L.A. MOD. (FINAL)
MODIFIED COMPRESSOR COMPARTMENT ACCESS DOOR

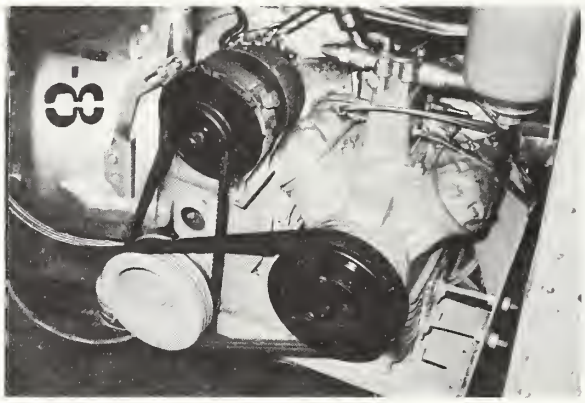


FIG. 22. L.A. MOD (FINAL) THERMO-KING COMPRESSOR, ALTERNATOR, MOUNTING AND DRIVE SYSTEM

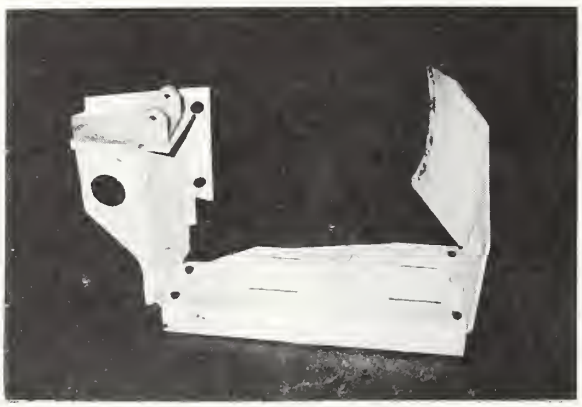


FIG. 23. L.A. MOD. (FINAL)
NEW THERMO-KING COMPRESSOR MOUNTING BASE

After the interior rear partition was removed for the A/C modification, it was noted that the electrical wiring conduit in each inside corner was carrying engine compartment oil fumes resulting in staining of the ceiling tiles. The conduits were sealed at the top opening, away from the heat of the engine.

Problems with internal refrigerant leaks in the Trane heat exchanger/ accumulator high-pressure liquid line mounting have contributed to many A/C failures. The line has a history of breaking away and leaking at the brazed joint which anchors the line to the inside of the rear end cap of the heat exchanger. Since the heat exchanger/accumulator is not used with Carrier compressors, Miami Metrobus is gradually changing over to these units.

5.3.2 Miscellaneous Modification by Los Angeles SCRTD

Los Angeles has also replaced the O.E.M. radiator fan with the one-piece fiberglass unit to eliminate the sheared bolt problem.

The O.E.M. evaporator blower motors presented the same problems as in Miami, with the result that L.A. has also used single speed motors as replacement alternatives.

Frequent repairs and replacement of the Trane compressors and clutches have been a major problem due to clutch and compressor malfunctions at start-up speeds normally existing in revenue service operation but higher than the units' upper start-up design limit. Los Angeles is switching over to Thermo-King compressors and clutches, both of which are designed to start up at any engine speed.

Trane heat exchanger/accumulator refrigerant leaks have proved to be as troublesome as those in Miami. Los Angeles has repaired the units by cutting the end cap off the heat exchanger, adding support, re-brazing the high pressure liquid line back to the end cap and re-welding the end cap to the heat exchanger cylinder. The external refrigerant lines have also been supported to minimize vibration-caused joint leaks.

6.0 MODIFICATION COSTS

Tables 4 through 8 summarize the general costs experienced by Miami and Los Angeles for each of the pertinent modifications.

TABLE 3
MIAMI METROBUS MOD. #1

AIR CONDITIONING MODIFICATION COSTS

Item	Description		Total Cost
1	Body Structural Labor (bus)	140 hrs. @ $25.00	$3,500.00 (est.)
2	A/C Mechanical Labor (bus)	32 hrs. @ $25.00	800.00 (est.)
3	Sheet Metal Duct & Partition	Fabricated by Metrobus	500.00 (est.)
4	Steel Framing & Weldments	Fabricated by Metrobus	250.00 (est.)
5	Electrical Components & Materials	Commercial Supplier	1,550.00
6	Mechanical Components & Materials	Commercial Supplier	625.00
7	O.E.M. Trane Compressor (major rebuild)	Metrobus Shops	1,000.00
8	Miscellaneous Materials and Hardware	Commercial Supplier	150.00
		Total Estimated Cost	$8,375.00

Notes: a) All cost figures furnished by Metrobus.

b) The labor and some of the materials costs for the Mod. #1 prototype design were actually higher than shown. This is due to the trial and error aspects encountered when developing a modification to an existing system for the first time. Based on the information provided in this report, it is assumed that this A/C modification can be accomplished for the same, or lower, cost.

(An itemized parts list is provided in Appendix C).

TABLE 4
MIAMI METROBUS MOD. (FINAL)

AIR CONDITIONING MODIFICATION COSTS

Item	Description		Total Cost
1	Body Structural Labor (bus)	128 hrs. @ $25.00	$3,200.00 (est.)
2	A/C Mechanical Labor (bus)	32 hrs. @ $25.00	800.00 (est.)
3	Fiberglass Parts	Commercial Fabricator	1400.00 (est.)
4	Steel Framing & Weldments	Commercial Fabricator	425.00 (est.)
5	Electrical Components & Materials	Commercial Supplier	1,550.00
6	Mechanical Components & Materials	Commercial Supplier	625.00
7	O.E.M. Trane Compressor (major rebuild)	Metrobus Shops	1,000.00
		Total Estimated Cost	$9,000.00

Notes: a) All cost figures furnished by Metrobus.
b) Actual bids from commercial fabricators had not been received at the time of this report.

(An itemized parts list is provided in Appendix C).

TABLE 5
LOS ANGELES SCRTD MOD. #1

AIR CONDITIONING MODIFICATION COSTS

Item	Description		Total Cost
1	Body Structural Labor (bus)	48 hrs. @ $25.00	$1,200.00
2	A/C Mechanical Labor (bus)	16 hrs. @ $25.00	400.00
3	Fabricated Items: Air Box Assembly, Motor Mounts, Louvered Panel, Frames, Brackets, etc.	32 hrs. @ $25.00	875.00
4	Raw Material	Commercial Supplier	150.00
5	Electrical Components	Commercial Supplier	900.00
6	Mechanical Components	Commercial Supplier	1,600.00
7	O.E.M. Trane Compressor (minor rebuild)	SCRTD Shops	450.00
		Total Estimated Cost	$5,575.00

Notes: a) All cost figures furnished by SCRTD.
b) The labor and some of the material costs for the Mod. #1 prototype design were actually higher than shown. This is due to the trial and error aspects encountered when developing a modification to an existing system for the first time. Based on the information provided in this report, it is assumed that this A/C modification can be accomplished for the same, or lower, cost.

(An itemized parts list is provided in Appendix C).

TABLE 6
LOS ANGELES SCRTD MOD. #2

AIR CONDITIONING MODIFICATION COSTS

Item	Description		Total Cost
1	Body Structural Labor (bus)	40 hrs. @ $25.00	$1,000.00
2	A/C Mechanical Labor (bus)	8 hrs. @ $25.00	200.00
3	Fabricated Items: Air Box Assembly, Motor Mounts, Louvered Panel, Frames, Brackets, etc.	31 hrs. @ $25.00	775.00
4	Raw Material	Commercial Supplier	165.00
5	Electrical Components	Commercial Supplier	900.00
6	Mechanical Components	Commercial Supplier	1,600.00
7	O.E.M. Trane Compressor (major rebuild)	SCRTD Shops	750.00
		Total Estimated Cost	$5,390.00

Notes: a) All cost figures furnished by SCRTD.
b. Based on the information provided in this report, it is assumed that this A/C modification can be accomplished for the same, or lower, cost.

(An itemized parts list is provided in Appendix C).

TABLE 7
LOS ANGELES SCRTD MOD. (FINAL)

AIR CONDITIONING MODIFICATION COSTS

Item	Description		Total Cost
1	Body Structural Labor (bus)	32 hrs. @ $25.00	$ 800.00
2	A/C Mechanical Labor (bus)	24 hrs. @ $25.00	600.00
3	Fabricated Weldments & Condenser Assembly	24 hrs. @ $25.00	600.00
4	Raw Material	Commercial Supplier	298.00
5	Electrical Components	Commercial Supplier	741.00
6	Mechanical Components	Commercial Supplier	960.00
7	Thermo-King A/C Compressor Kit	Supplied by Thermo-King	2,500.00
		Total Estimated Cost	$6,499.00

Notes: a) All cost figures furnished by SCRTD and reflect the following:
- o Labor hours were determined by actual time studies
- o Fabricated weldments are produced in lots of 25 to increase efficiency and decrease unit cost
- o Various commercial components are purchased with volume discounts.

b) Item #7 includes new design mounting base.

(An itemized parts list is provided in Appendix C).

7.0 EVALUATION OF AIR CONDITIONING MODIFICATIONS

The effectiveness of the changes to their AMG buses made by Metrobus and SCRTD can be assessed by measuring the gains in reliability and fuel economy, the major goals of the transit agencies' modification efforts. As a measure of reliability, an analysis was done of air conditioning system related road calls, i.e., "no A/C", "hot engine", "no start", "stall", experienced during the 1982/83 time period at Miami and Los Angeles.

At Metrobus, an examination of maintenance records for 5 modified buses prior to their alterations, as well as the data on 13 other, randomly selected, buses revealed that 431 A/C related road calls were made for these buses in 11 months. This is an average of 2.3 such incidents per bus per month ("bus-month"). In contrast, the test buses, after being modified, had a total of 19 A/C related road calls during this time for a 0.83 average, indicating a 64% reduction in road calls for the modified coaches (Table 9).

In Los Angeles, the maintenance data shows that 116 A/C related road calls were made for 28 unmodified [test and control] buses during an 8 month period for an average of 0.61 incidents per bus-month. However, after being modified, 8 of these buses experienced only five road calls during this time for a 0.15 average or a 76% reduction in A/C breakdowns (Table 10).

TABLE 8
Miami Metrobus
A/C Related* Failures/Road Calls

1982

Test Bus Number	Jan.	Feb.	Mar.	Apr.	May	June	July	Sep.	Oct.	Nov.	Dec.	Totals Before	Totals After
628	0	0	1	1	0	1	2	0	1	0	0	0	6
654	1	0	5	2	0	0	0	2	2	1	0	8	5
678	2	2	6	6	2	0	0	1	0	4	0	18	5
620	0	0	10	4	3	7	3	2	2	0	1	29	3
625	0	0	10	2	2	5	6	1	0	1	0	27	0
												82	19
Control Bus Number													
615	1	0	1	0	2	6	2	4	1	1	2	20	
616	0	0	5	1	1	3	2	1	0	3	1	17	
618	1	3	2	2	4	5	6	1	0	1	0	25	
623	0	1	0	1	1	3	0	6	3	2	4	21	
626	0	0	0	1	3	1	1	0	2	0	1	9	
641	1	3	0	2	1	1	2	3	2	4	1	20	
656	5	4	2	0	1	0	8	3	2	0	0	25	
657	7	1	5	0	1	1	8	14	0	6	7	50	
668	2	4	4	2	0	3	3	4	3	1	2	28	
691	2	4	1	2	1	3	8	3	5	2	3	34	
692	1	4	16	8	3	6	13	4	4	4	0	63	
704	0	4	4	0	2	5	2	1	2	1	1	22	
705	2	1	2	0	0	0	0	2	3	1	4	15	
												349	

*No A/C, No Start, Hot Engine, Stall

Note: Division line indicates approximate date of bus modification.

TABLE 9
Los Angeles SCRTD
A/C Related* Road Calls

Test Bus Number	Report Date 1982 7/10	8/14	9/11	9/25	10/16	10/30	11/26	1983 1/1	2/12	Totals Before	Aft
8075	0	1	1	1	1	0	0	0	0	0	4
-76	1	0	0	0	0	0	0	0	0	1	0
-77	1	1	0	0	0	0	0	0	1	2	1
-78	1	0	0	0	0	0	0	0	0	1	0
-79	0	1	2	1	0	0	0	0	0	4	0
-80	0	0	1	0	0	0	0	0	0	1	0
-81	1	3	0	0	0	0	0	0	0	4	0
-82	1	4	4	1	1	0	0	0	0	11	0
										24	5
Control Bus Number											
8065	1	0	0	0	0	0	0	0	0	1	
-66	1	3	1	2	0	0	0	0	0	7	
-67	0	3	1	1	1	1	0	0	0	7	
-68	1	3	1	0	0	0	0	0	0	5	
-69	0	1	1	1	0	0	0	0	0	3	
-70	0	3	0	0	0	0	0	0	0	3	
-71	0	0	0	0	0	0	0	0	0	0	
-72	0	3	0	0	0	1	0	0	0	4	
-73	2	1	1	1	0	0	0	0	0	5	
-74	0	0	0	1	0	0	0	0	0	1	
-84	0	0	0	0	1	1	1	0	0	3	
-85	0	3	1	1	0	1	0	0	0	6	
-86	0	0	0	0	0	0	0	0	0	0	
-87	0	0	0	0	0	0	0	0	0	0	
-88	1	1	0	0	1	1	0	0	1	4	
-89	1	0	2	1	3	2	0	0	0	9	
-90	1	7	1	0	0	0	0	0	0	10	
-91	1	3	3	6	1	0	0	0	0	14	
-92	1	0	2	0	0	0	0	0	0	3	
-93	1	5	1	0	0	0	0	0	0	7	
										92	

*No A/C. Hot Engine, No Start

Note: Division line indicates approximate date of bus modification.

Assessing the effects of the air conditioning modifications on fuel economy is a much more difficult and complex task. Many factors affect this parameter on a day-to-day and even month-to-month basis. Among these are types of routes traveled (central business district, arterial or commuter), street grades, stops per mile, passenger loadings, operator driving habits, etc. Within the scope of this study it was not possible to obtain the type and/or quantity of data needed to verify that the air conditioning modifications are responsible for any change in fuel economy for the altered buses.

In order to obtain more definitive results, a specific, long term data collection effort with a larger [modified bus] sample size is necessary. At this time, however, basic engineering judgment indicates that the modified buses should experience, if not significant, at least somewhat better fuel usage. Although offset by a slight total weight increase, the lower compressor discharge pressures, lower engine and transmission temperatures and lighter engine cooling fan are factors that would tend to increase overall fuel economy.

APPENDIX A

MODIFICATIONS TO MIAMI AMG-9640B BUSES

Detailed photographs and procedures for:

- A/C system bus body modifications
- A/C system mechanical modifications

Miami Metrobus
Procedures for AMG-9640B
A/C Body Modifications

Mod. #1	Mod. (Final)	Step No.	
X	X	1.	Remove rear window outside panel; open either left or right rear side window (to remove and replace rear wall).
X	X	2.	Remove tail gate.
X	X	3.	Remove rear five-passenger bench seat and the 2 rear-most 2-passenger seats.
X	X	4.	Remove rear center ceiling light fixture (To be modified and reinstalled).
X	X	5.	Cut both hand rails in center of the tee support.
X	X	6.	Remove left & right upper corner and inside corner trim of rear section.
X	X	7.	Remove left & right rear ceiling panels and cut ceiling mounting channels even with the remaining ceiling panel.
X	X	8.	Remove upper and lower rear panel trim (fiberglass).
X	X	9.	Remove and discard upper rear panel reinforcement mounting (#5973618).
X	X	10.	Cut rear outside upper panel (#5963618) to 38.5" H x 50" W on center line.

NOTE: The symbol (X) indicates that Mod. #1 procedures are essentially the same as in Mod. (Final) and component dimensions and overall configuration for a non-fiberglass modification can be taken from the Mod. (Final) Metrobus fabricated parts lists.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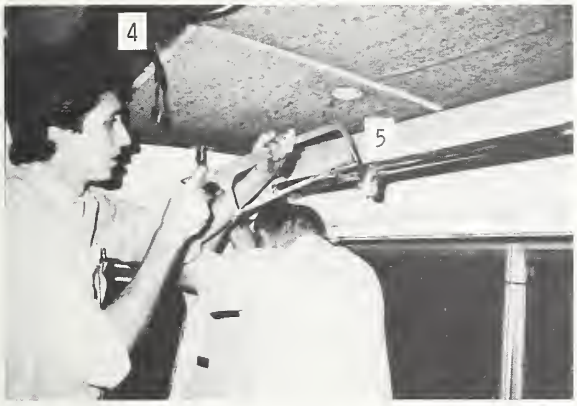
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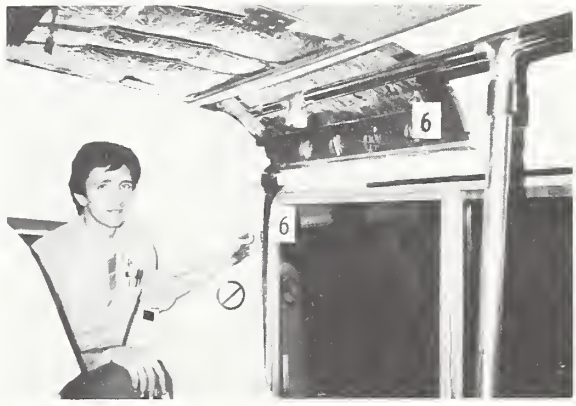
6
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7
7


8


9


10
50"
METROBUS
38 1/2"

Mod. #1	Mod. (Final)	Step No.	
X	X	11.	In order to support the roof at the forward edge of the new intake air opening while providing a stop to secure the ceiling tiles and the new fiberglass rear partition, the first roof bow assembly at the rear of the bus must be removed, modified and relocated to establish a clear roof area 16-1/2" from the rear roof arc. Establish a dimesion 14-1/2" from the rear arc (#5955254) to the roof channel insert center (#5951903) and 16-1/2 to the left and right ceiling channels (#596950); cut out and discard insert and ceiling channels after the roof bow left (#5973489) and right (#5973488) have been cut free and complete assembly removed.
X	X	12.	Relocate and weld the left and right roof bows even with ends of the newly cut ceiling channels, providing a 16-1/2" roof clearance area for the air intake opening, frame and duct. The insert roof channel center should extend 2" beyond the roof bow and be riveted to the air intake grill frame and the roof, anchoring the roof channel center. Angle iron framing may be used in place of OEM roof bow.
X	X	13.	Remove existing rivets from the roof skin, 52" long on center line, for riveting to new intake grill frame assembly.
(X)	X	14.	Use air intake grill frame assy. #M15 as a template and transfer rivet holes thru roof from inside of bus for 3 sides, and from roof of bus for one side using original rivet holes in roof.
X	X	15.	Cut roof air intake opening within the intake grill frame assy. Note opening size is smaller than frame (11 1/4" x 48" with 4"R corners) to receive rubber seal (as used in glass destination sign).
X	X	16.	Install air intake grill frame using plastic caulking compound between frame and inside of roof. Use 3/16" dia. solid aluminum rivets to secure frame to roof.

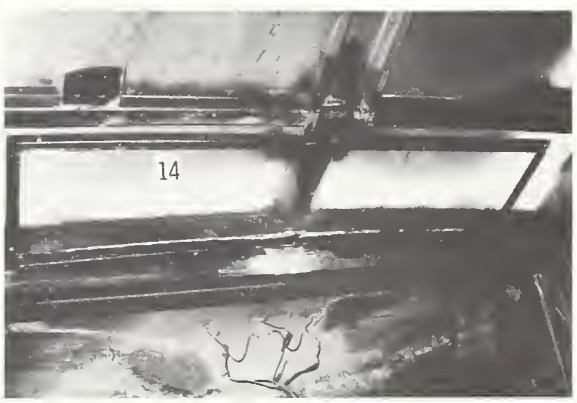

11


12


12


12


657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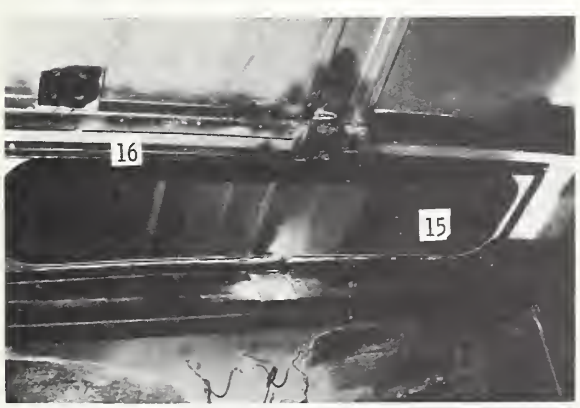
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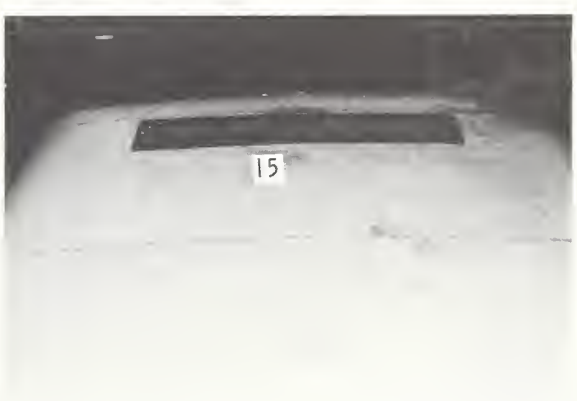
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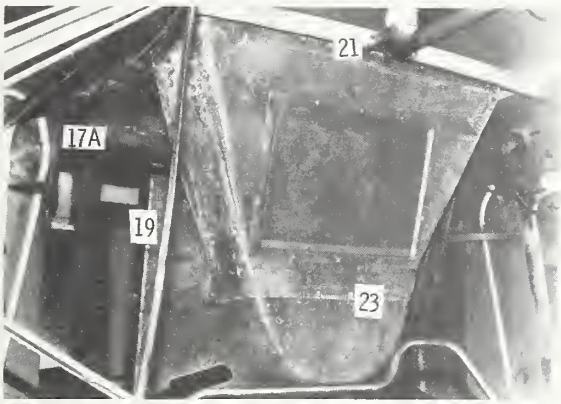
Mod. #1	Mod. (Final)	Step No.	
(X)	X	17a.	Weld condenser frame components, #M6 top frame member angle and #M12 main support member, upper (3" x 2" x 1/4" angle 66 1/2" long).
		b.	Two (2) each vertical side support channels, #M13 (3" x 1 1/2" x 3/16" U channel, 38 1/4" long).
		c.	Two each frame base angle (3" x 2" x 3/16" angle 30 1/2" long - weld on each end only).
(X)	X	18.	Install condenser brackets (weld) #M5 (2 each) to the left side (top & bottom) and #M2 (2 each) to the right side. The 4 brackets are located so that condenser is centered in the frame opening. (In-house jig is used to simplify location).
(X)	X	19.	Install condenser fan shroud frame #M2.
(X)	X	20.	Install drain pan #F8 and provide drain holes in engine compartment fire wall.
(X)	X	21.	Install intake air duct #F3&4 to air intake grill frame. (Note: Drill 4 holes and use 4 removable bolts to hold unit in place until condenser fan shroud #F7 is checked for proper fit and alignment).
(X)	X	22.	Using pop rivets, attach condenser fan shroud #F7 and drain pan to frame #M2. (Note: Be sure to check for alignment prior to permanently riveting units together).
(X)	X	23.	Using a sealing compound and pop rivets, attach the condenser fan shroud #F7 to the intake air duct #F3&4. (Note: Rivet from inside of duct).
(X)	X	24.	Transfer holes from #M15 air intake grill frame to fiberglass intake duct. Permanently pop rivet from inside of duct. (Note: On all fiberglass, use 3/16" rivets and back-up washers).
X	X	25.	Attach seal (GMC #224679) to condenser fan shroud with suitable adhesive. (Note: The horizontal seal on the top lip of the shroud must butt and seal against the right and left vertical seals. The bottom shroud seal must have a 1/2" gap on both the right and left sides to allow for rain water drainage).
(X)	X	26.	Install roof intake air seal and grill.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17A
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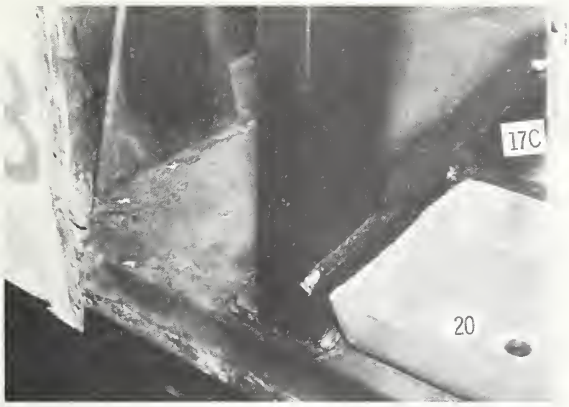
23


17B
22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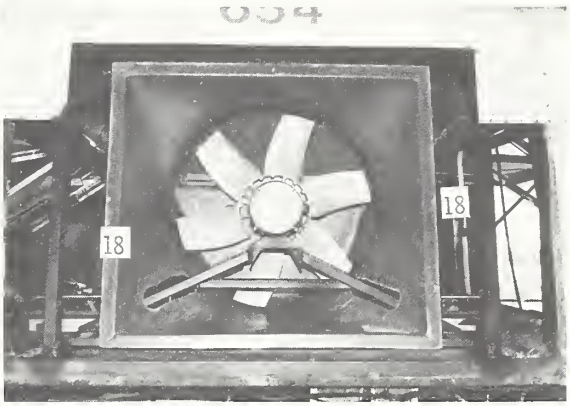
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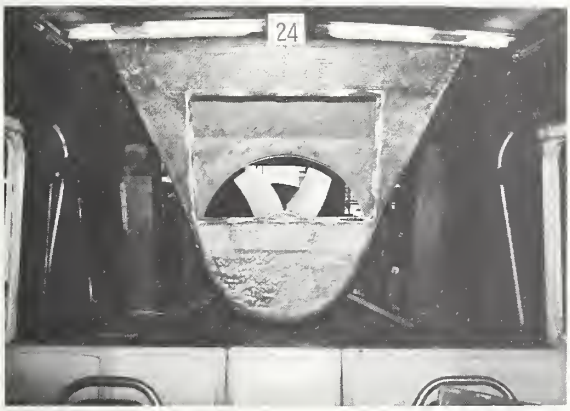
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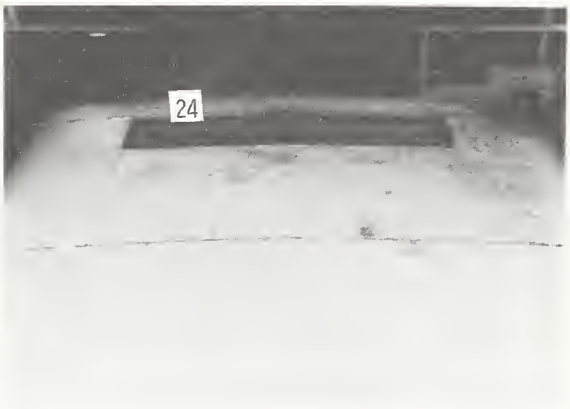
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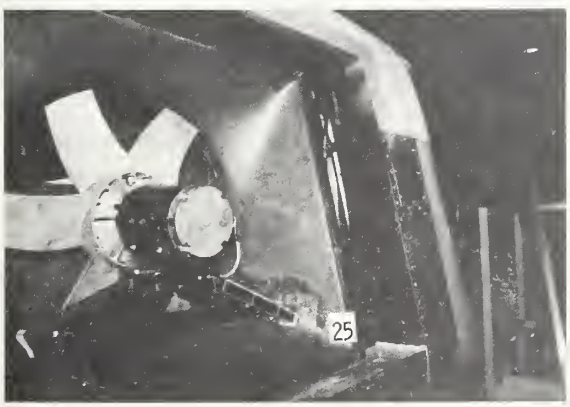
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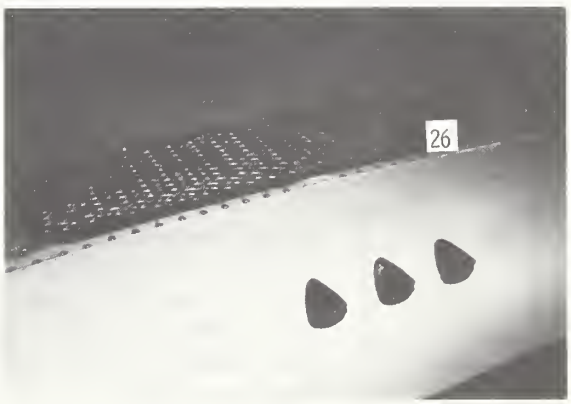
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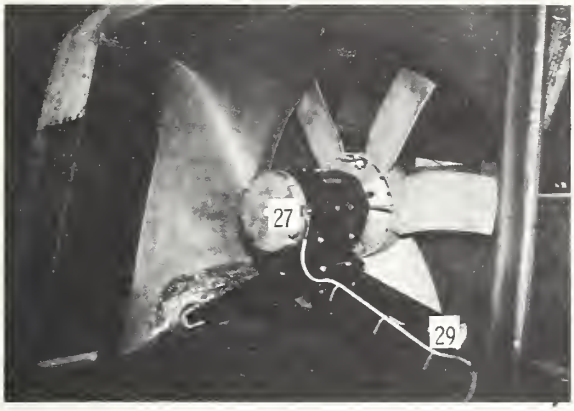
Mod. #1	Mod. (Final)	Step No.	
(X)	X	27.	Install condenser fan motor support assembly. Attach fan motor and fan to support. Check alignment and clearance of fan.
(X)	X	28.	Fiberglass the clearance opening around the legs (#M1A-M1B, right & left) to provide a watertight seal. Use fiberglass to seal any other false holes or construction faults.
X	X	29.	Attach wiring to fan motor leg, and drill hole in fiberglass shroud at motor level and wire motor. (Use grommet; see schematic for wiring).
X	X	30.	Attach condenser to frame mount. (Note: Condenser should be pressed firmly against rubber shroud seal and locked in place.)
X	X	31.	Provide 3 suitable clearance holes in engine fire wall to receive the A/C supply & return lines plus one hole for the fan motor wire. (Note: Use rubber grommets on all access holes).
X	X	32.	Connect the supply & return refrigerant lines to condenser. (Note: If the Trane compressor is used, be sure to use the OEM check valve on the condenser supply line).
(X)	X	33.	Install #M19 panel bottom and tail gate hinge. Install #M17 exterior panel left side and #M18 exterior panel right side. (Note: Access door is in the right panel). Return lip of #M19 is placed to direct rain water to drain pan. When drilling holes for sheet metal screws, do not drill into drain pan—use flat-tip sheet metal screws. Use caulking compound to seal openings in sheet metal components; this will stop water from dumping when bus starts moving.
X	X	34.	Prime & paint exterior rear end of bus where new skin was attached.
(X)	X	35.	Locate exterior louver #F6 on center of bus, using the flat portion jist below the drain pan for bottom location (see OEM drawing of rear framework). Note: Top section requires drilling and tapping into angle iron frame— other areas require 1/4-20 UNC rivet nut in aluminum skin.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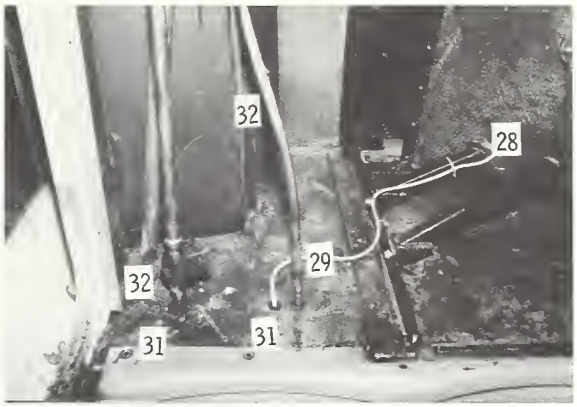
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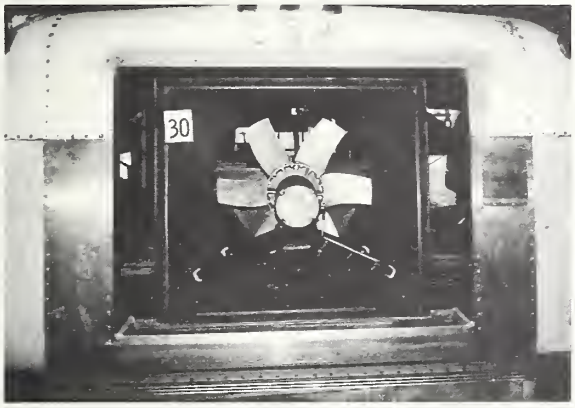
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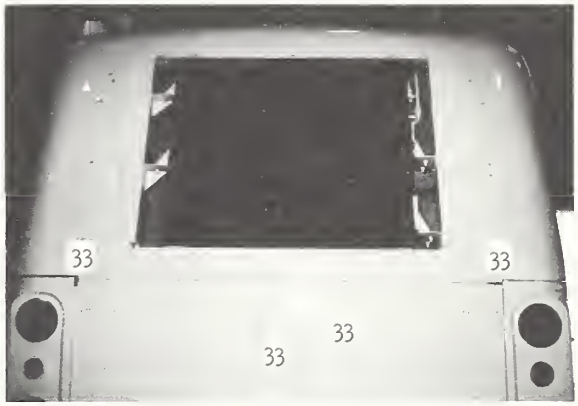
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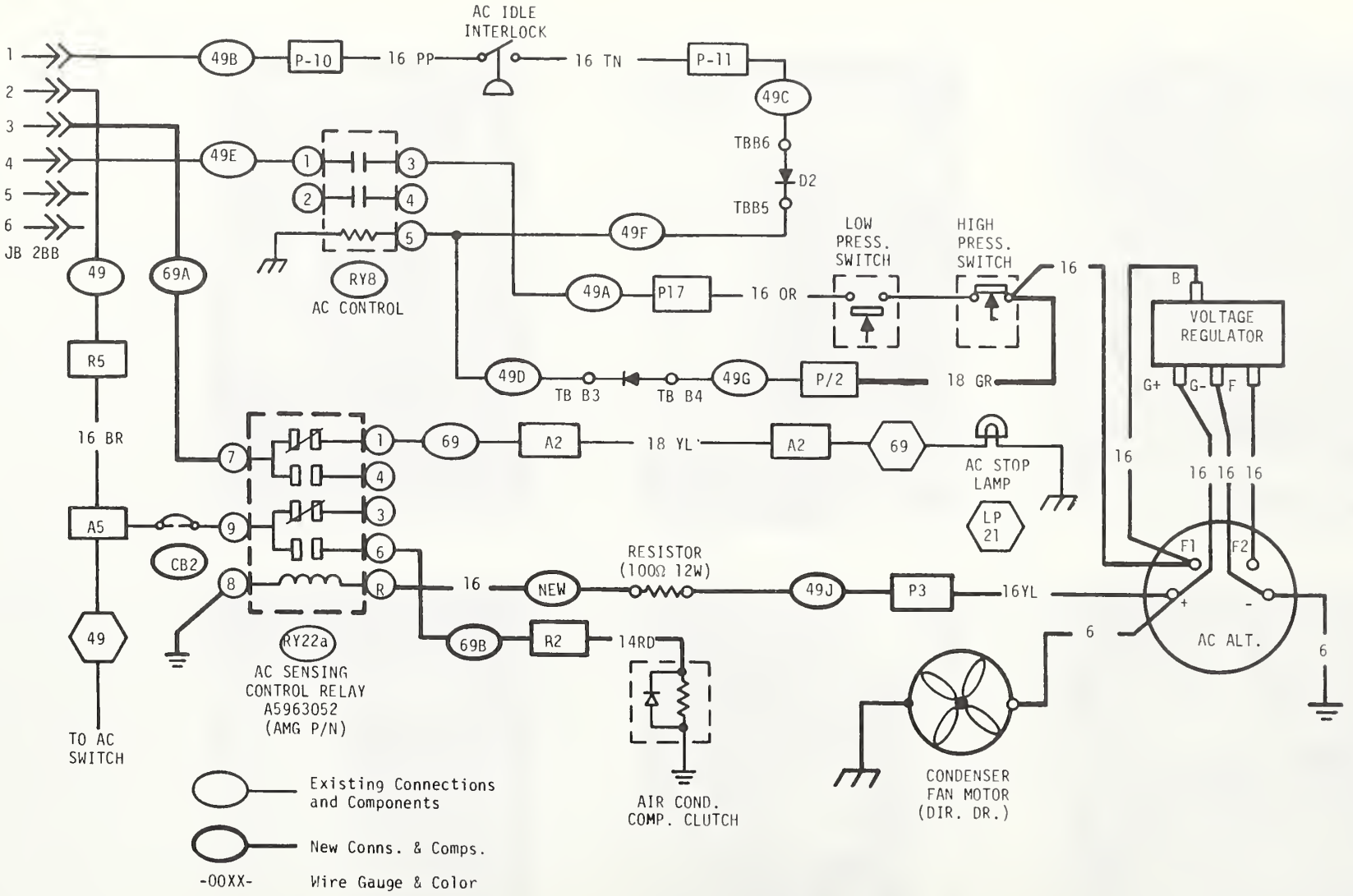

MIAMI METROBUS MODIFIED A/C SYSTEM WIRING DIAGRAM

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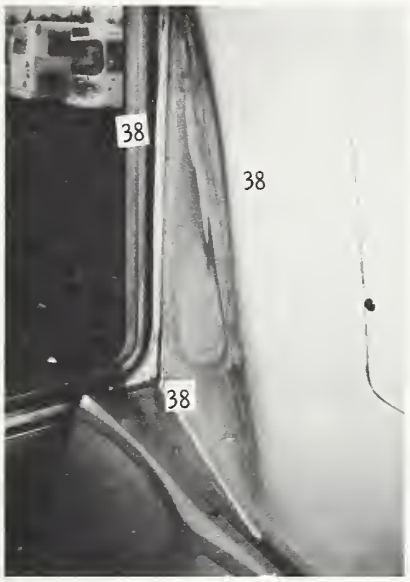
Mod. #1	Mod. (Final	Step No.	
X	X	36.	Attach tailgate.
(X)	X	37.	Attach intake air duct access door to air duct (method of attachment optional); use a suitable gasket material for a seal (Note: Must be capable of removal. Also pressure test A/C system before proceeding to step 38.)
(X)	x	38.	Replace left and right inside rear corner window trim. Attach a suitable piece of aluminum angle to the full length. This angle will be used to secure the sides of the new #F1 interior partition with pop rivets. Install #F1 partition. The top or ceiling edge of #F1 is secured to the ceiling bow with pop rivets. Bottom edge fits between #M20A & #M20B interior partition attaching angles. #M20A &#M20B use the same holes used on rear seat hinge; the hinge is also part of this assembly. The right & left bottom wings of the interior wall must be drilled on location for triangular hold-down plates attached with sheet metal bolts. Modify rear seat hinge to suit assembly (seats are part of the hinge).
(X)	X	39.	Attach rubber gasket to access door and screw to wall of #F1 (special security screw is used; GMC #2035451 and 2035450 nut).
X	X	40.	Replace ceiling panels and modified light fixture. Modify light fixture to use a standard 4-foot flourescent bulb. Lens of fixture to extend to rear wall.
X	X	41.	Cut and install hand rails.
(X)	X	42.	Install radiator baffle box (#M16).
X	X	43.	Install engine, transmission and radiator access doors, and all rear seats.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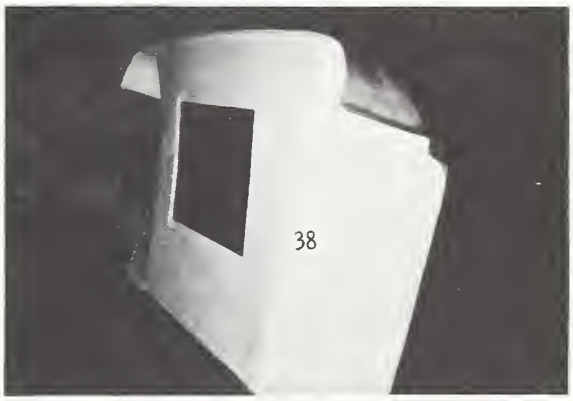
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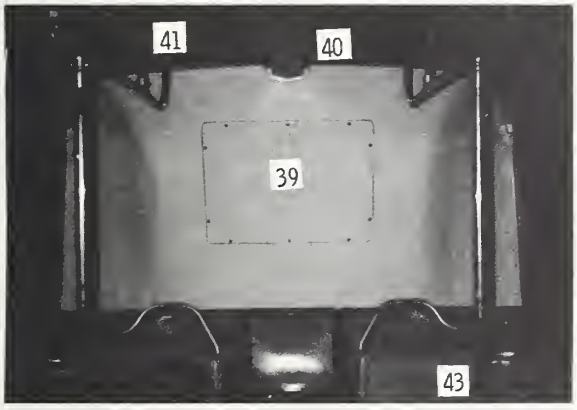
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Miami Metrobus
Procedures for AMG-9640B
A/C Mechanical Modifications

Mod. #1	Mod. (Final)	Step No.	
X	X	1.	Evacuate refrigerant from the A/C system.
X	X	2.	Remove condenser and plumbing; clean and pressure test for leaks.
X	X	3.	Remove A/C compressor drive belt, tensioning air cylinder, compressor, and mounting base. Cap the tensioning air cylinder air supply line.
X	X	4.	Remove and discard refrigerant Hi-Lo switch and flexible A/C hoses.
X	X	5.	Remove or disconnect relay RY22 from rear apparatus control box and install new relay RY22a and resistor. (See Modified Wiring Diagram).
X	X	6.	Remove and discard transmission shifting cable mounting bracket.
X	X	7.	Install new A/C compressor mount.(RTS)
X	X	8.	Relocate shifting cable through A/C compressor mounting assembly (Make suitable bracket).
X	X	9.	Install compressor, clutch, pulley, coil and lines.
X	X	10.	Install new high and low pressure switches in compressor.
X	X	11.	Install new alternator #70-1886-9(Flxible) using alternator mounting block, and weld to suit.


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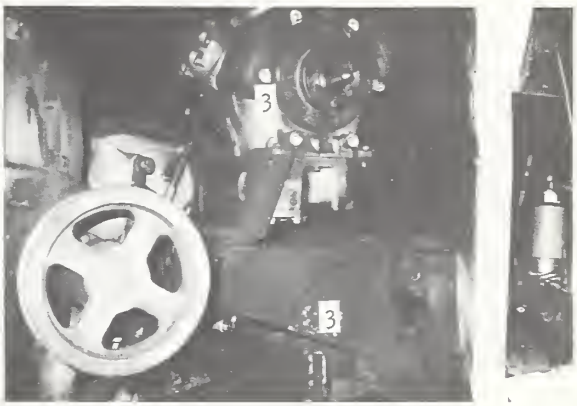
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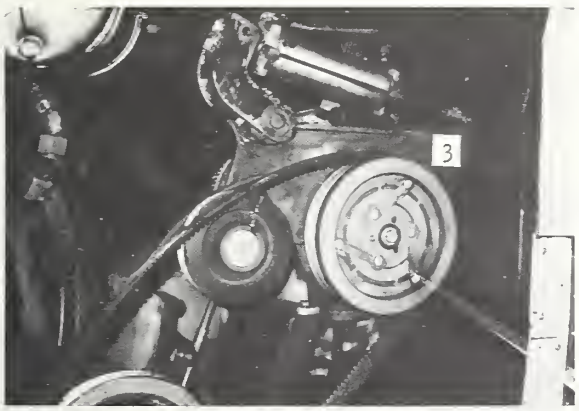
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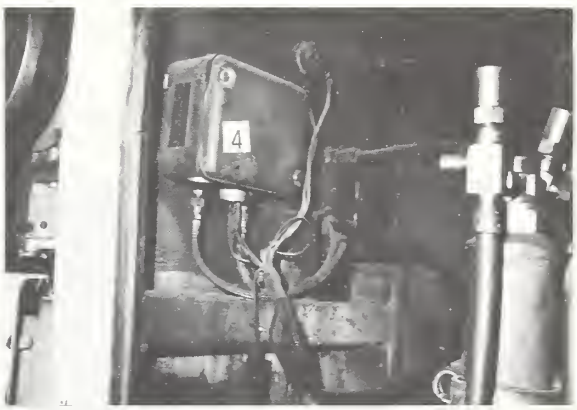
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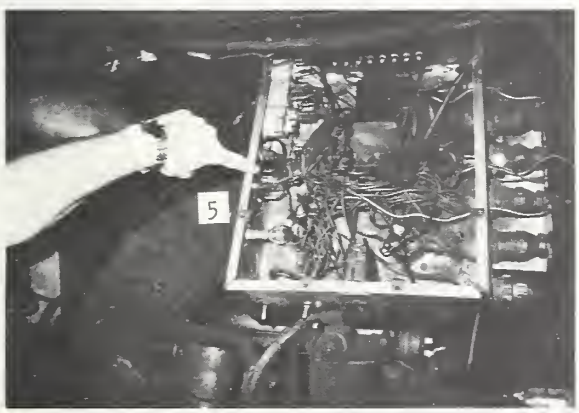
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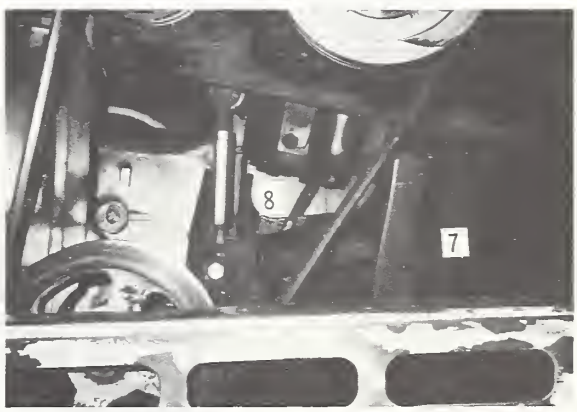
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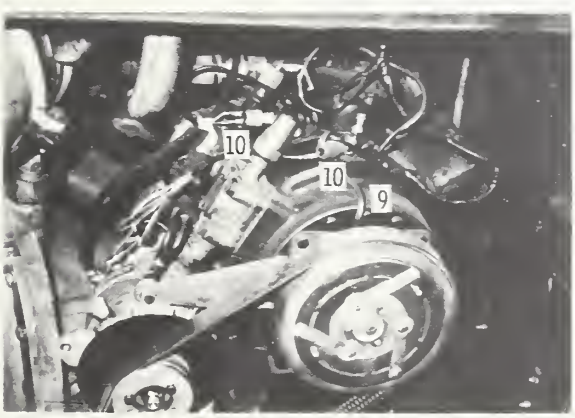
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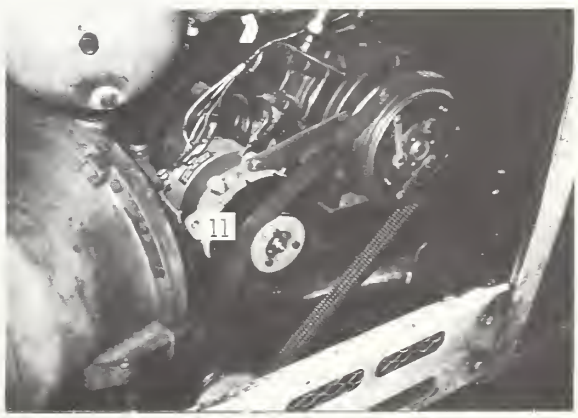
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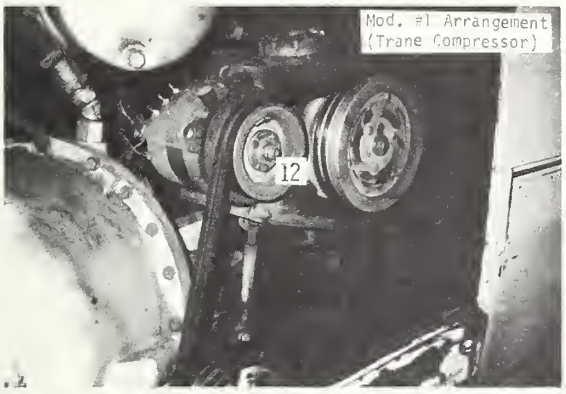
Mod. #1	Mod. (Final)	Step No.	
	X	12.	Attach alternator pulley on alternator using belt and alternator support arm #M10 (Arm is connected from alternator to compressor).
X	X	13.	Install voltage regulator in the same place used for the removed OEM Hi-Lo switch.
X	X	14.	Wire system in accordance with modified A/C wiring diagram. (Note: Heat exchanger is bypassed when Carrier compressor is used.)
X	X	15.	Install a new dryer-filter (dehydrator); evacuate the system and charge with Freon-22.


Mod. #1 Arrangement
(Trane Compressor)
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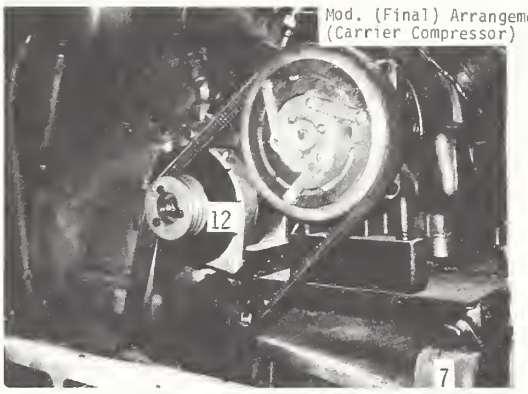
Mod. (Final) Arrangement
(Carrier Compressor)
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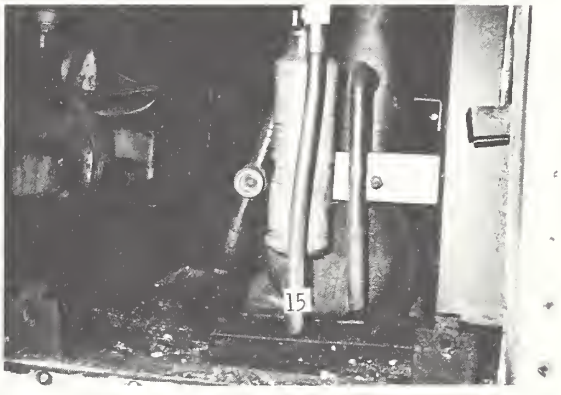
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APPENDIX B

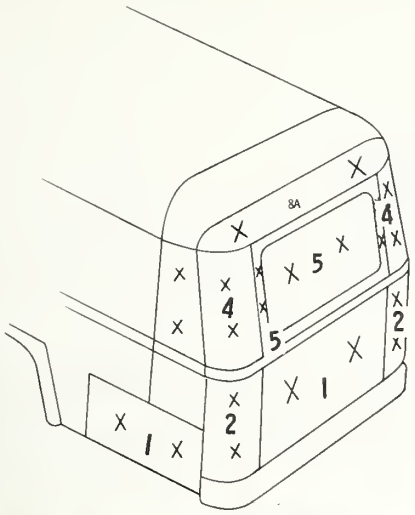
MODIFICATIONS TO LOS ANGELES AMG-10240B BUSES

Detailed photographs and procedures for:

- A/C system bus body modifications
- A/C system mechanical modifications

Los Angeles SCRTD
Procedures for AMG-10240B
A/C Modifications

Mod. #1	Mod. #2	Mod. (Final)	Step No.	
X	X	X	1.	Remove engine, transmission and radiator access doors.
X	X		2.	Remove panels containing tail light assemblies.
X	X	X	3.	Remove air cleaner access door and air cleaner.
X	X		4.	Drill out rivets and remove upper exterior corner panels.
X	X	X	5.	Remove rear window, window frame and rear window exterior panel.
X	X	X	6.	Remove rear window interior panel (Note: In order to remove interior rear window panels, it is necessary to remove right and left rear dome light assemblies and both rear-most, 2-passenger seats as well as the five-passenger bench seat cushions and back to maximize work space.)
X	X	X	7.	Remove and discard upper rear panel reinforcement mounting.
X	X		8.	Cut rear outside upper panel to roof arc on center; stamp air intake louvers in removed section (to be reinstalled).
		X	8a.	Cut rear outside upper panel flush with rear structural panels and approximately 14" vertically.
X	X	X	9.	Remove exposed interior insulation.
X	X	X	10.	Grind rivet stumps flush.
X	X	X	11.	Steam clean interior work area to remove residual fiberglass insulation to prevent possible breathing or skin irritation hazards.
X	X	X	12.	Prime-paint exposed interior metal surfaces.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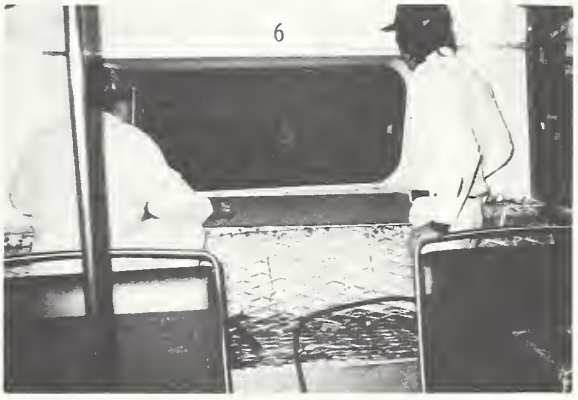
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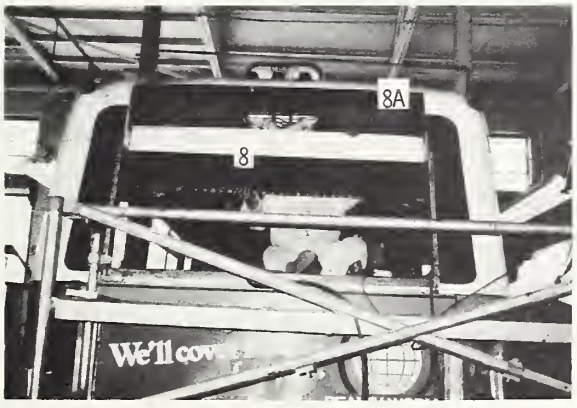
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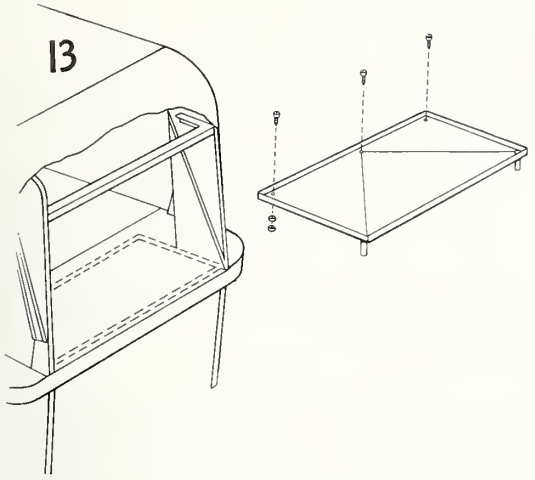
Mod. #1	Mod. #2	Mod. (Final)	Step No.	
X	X		13.	Install drain pan. Raise interior edge with two (2) each "Ad Sign" spacers at three locations and affix with #10 x 2" Tek Screws.
X	X		14.	Install "New-Look" condenser and stiffener brackets with 3/8" x 1-1/4" S.A.E. cap screws. Care should be taken to maintain the 66" dimension between the stiffener plates to insure proper mounting of air box sides and motor bracket.
X	X		15.	Modify condenser by removing stock union fittings. Silver solder pipes and new unions in their place as shown. Install condenser. Leave 3/4" clearance between the lowest point of the condenser frame and the drain pan.
	X		16.	Install air box sides. Butt the sides against the condenser brackets and affix with three 1/4" x 3/4" Tek screws per side into the stiffeners.
X	X		17.	Continue plumbing condenser through the air box side along the stiffener and through the coach tray.
	X		18.	Install motor bracket.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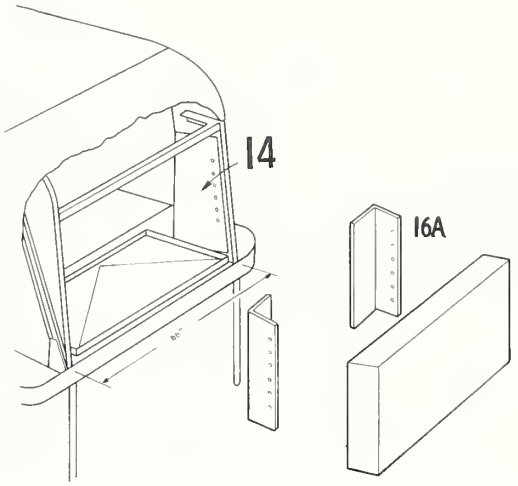
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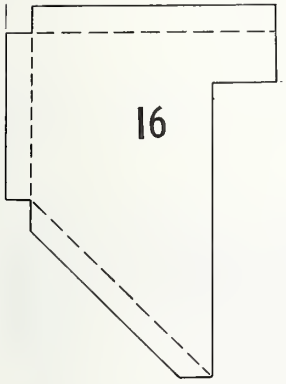
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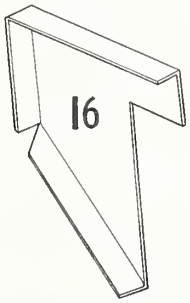
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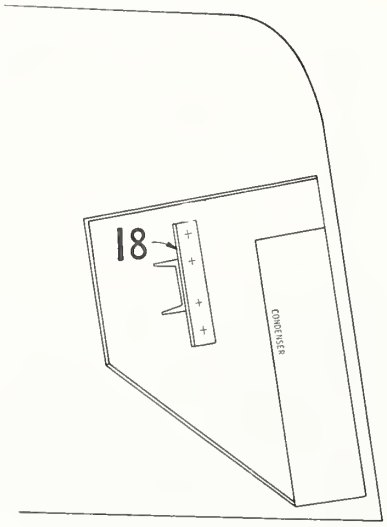
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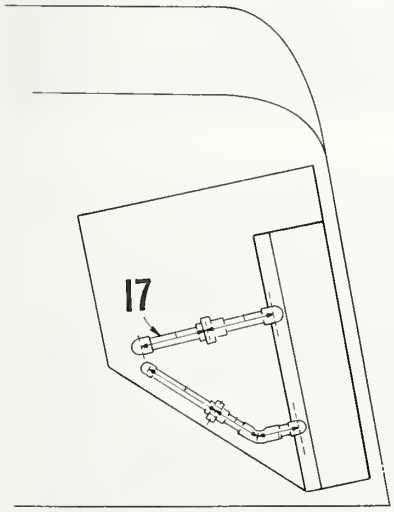
CONDENSER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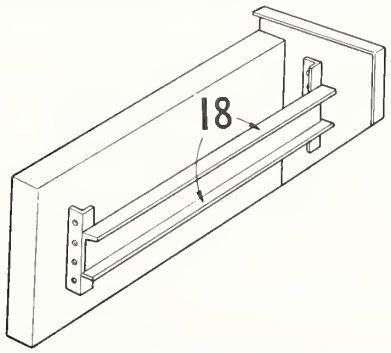
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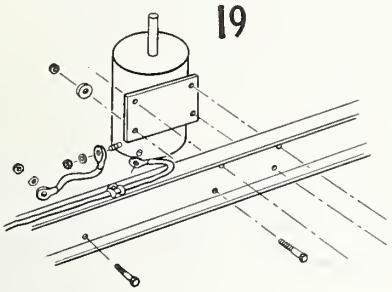
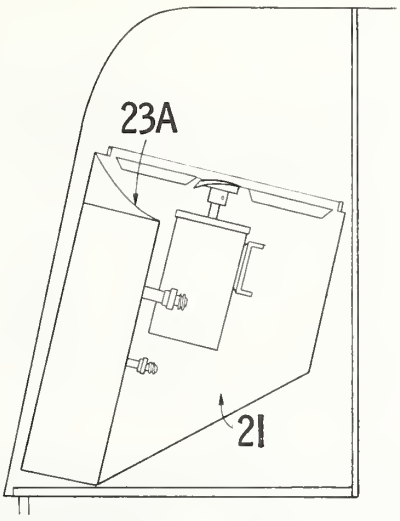
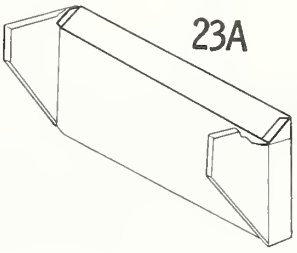
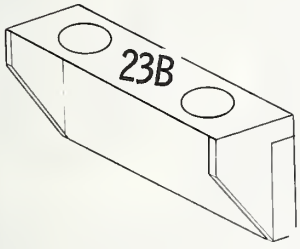
Los Angeles SCRTD
Procedures for AMG-10240B
A/C Modifications

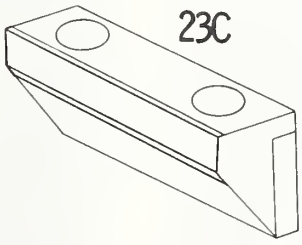
Mod. #1	Mod. #2	Mod. (Final)	Step No.	
X	X		19.	Install condenser fan motors and connect wires.
X			20.	Complete air box assembly for horizontal mounting of motor.
	X		21.	Complete air box assembly for vertical mounting of motor.
X	X		22.	Install fan hubs and fans.
	X		23.	Install a) incline panel, b) air box top, c) liner panel, and d) mid-panel.
X	X		24.	Reinstall (rivet) rear upper louvered panel.
X			25.	Note: In Mod. #1, the horizontal orientation of the condenser fans (step #20) results in an air flow pattern that is localized to the fan blade areas. Unless distribution vanes are used, the vertical mounting configuration (step #21) would be more efficient.

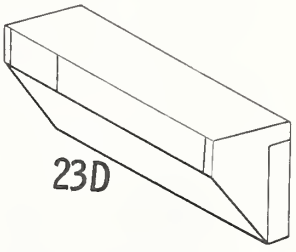


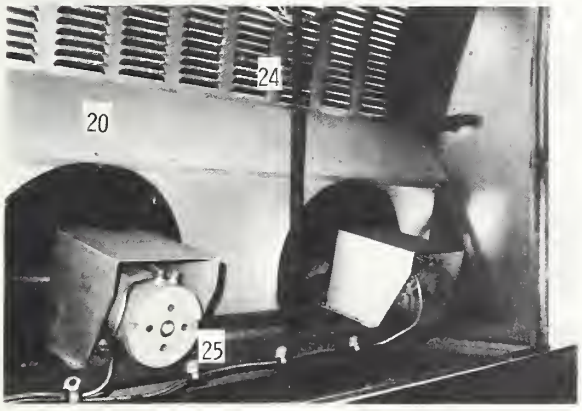












VIEW OF LOUVERS IN BUS BODY

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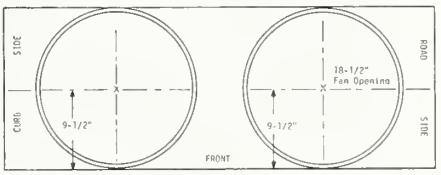
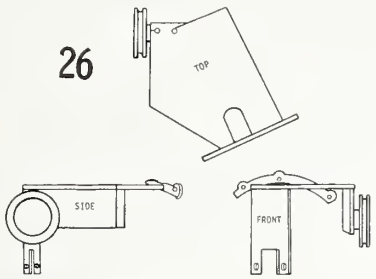


Mod. #1	Mod. #2	Mod. (Final)	Step No.	
X			26.	Install alternator bracket
	X		27.	Install alternator bracket using the existing transmission housing bolts. (Modified & improved design)
X			28.	Install alternator.
	X		29.	Install alternator.
X	X		30.	Reroute transmission oil filter outlet line. Remove existing PTO pulley and replace with the three-groove, two-piece pulley assembly (fabricated by RTD shops).
		X	31.	Relocate transmission oil filter to engine compartment bulkhead.
X	X	X	32.	Evacuate refrigerant from the A/C System.
X	X	X	33.	Remove the original condenser and plumbing; clean radiator.
X	X	X	34.	Install radiator baffle box.
		X	35.	Install pre-assembled plenum chamber, consisting of condenser, fan shroud and fan/motor assemblies, using 18" dia. fans, in rear opening of bus.
		X	36.	Recess plenum chamber 1/4 inch, and center in opening.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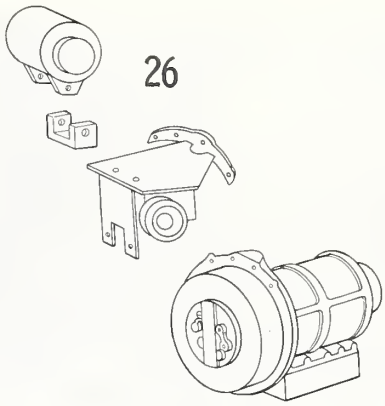
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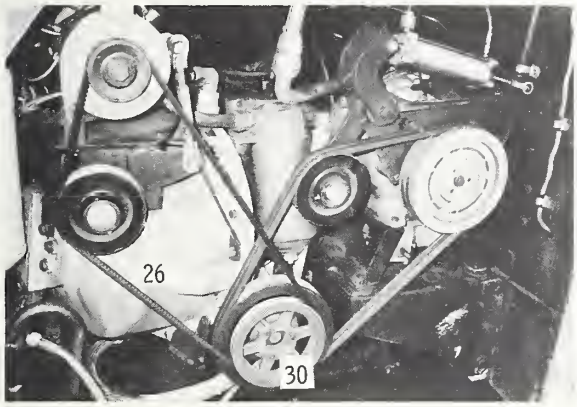
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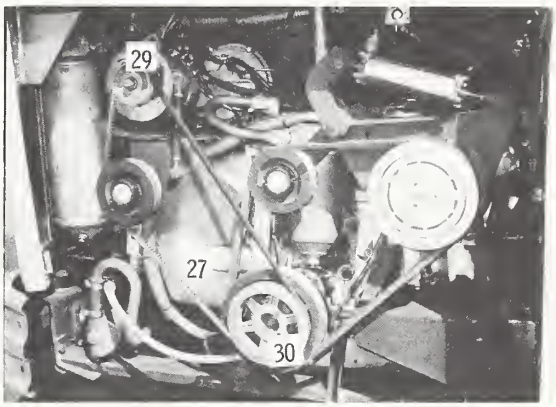
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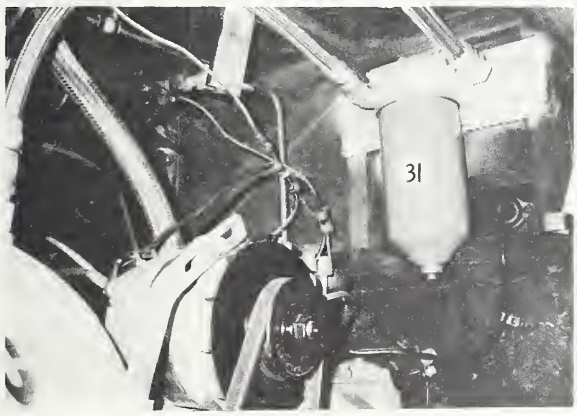
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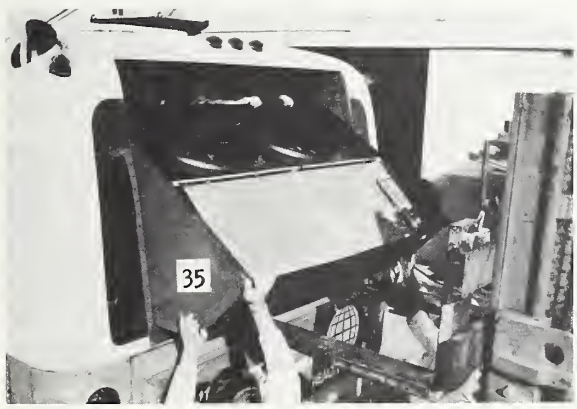
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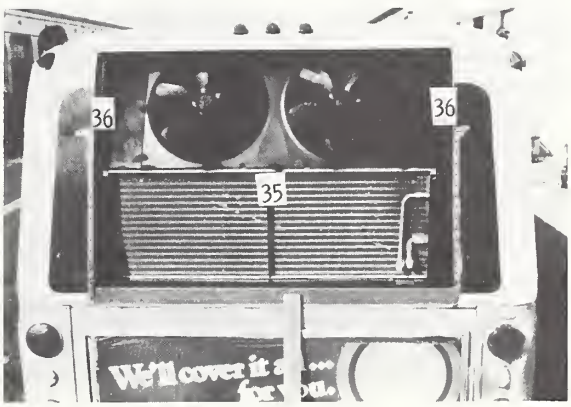
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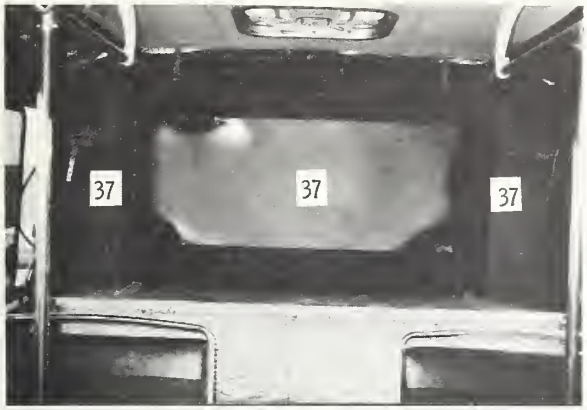
Mod. #1	Mod. #2	Mod. (Final)	Step No.	
		X	37.	From inside bus, weld plenum chamber to left and right engine bulkhead panels (#5974643 and #5967570) using 4 ea. 3" x 3" x 5/16" steel angles as shown.
		X	38.	Cut to fit a 1/8" steel plate on each side of plenum, skip weld in place and seal all joints of plenum chamber with silicone (RTV) caulking.
		X	39.	After completing wiring and plumbing, seal all openings and water test plenum chamber with fans running (no A/C compressor). Perform this test prior to installing the rear interior partition. Insulate plenum chamber
		X	40.	Install louvered panel.
X	X	X	41.	Install protective grill over condenser.
X	X	X	42.	Install framing for interior rear partition.
X	X		43.	Install rear partition (with service access door/panel).
		X	44.	Install rear partition (no access door).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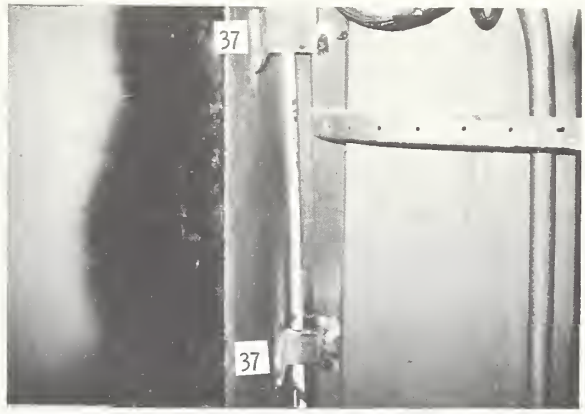
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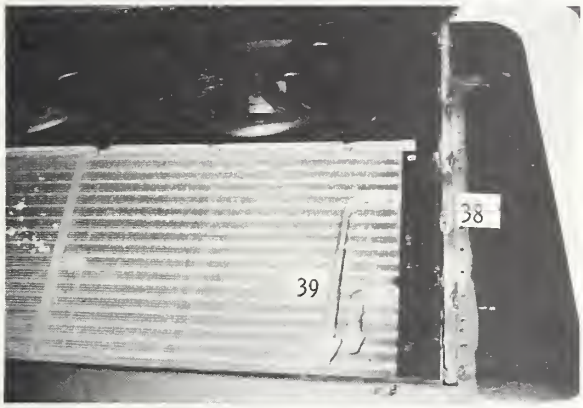
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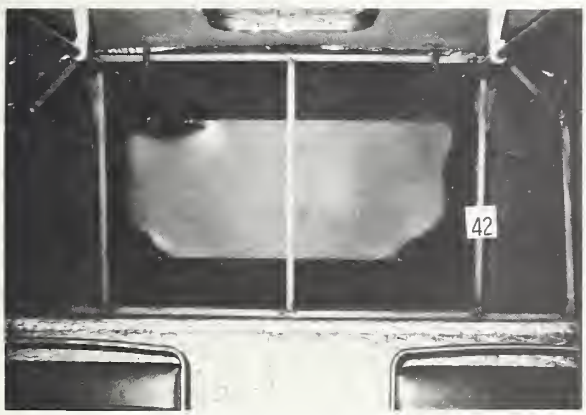
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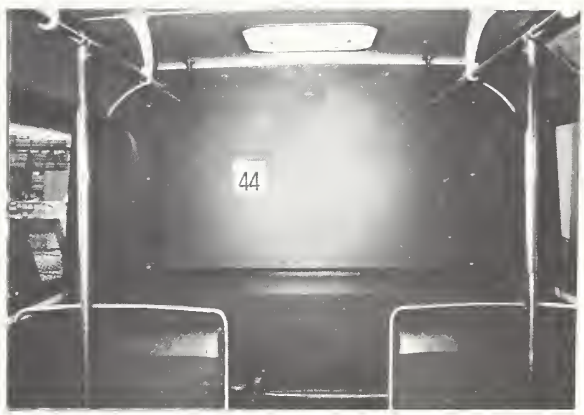
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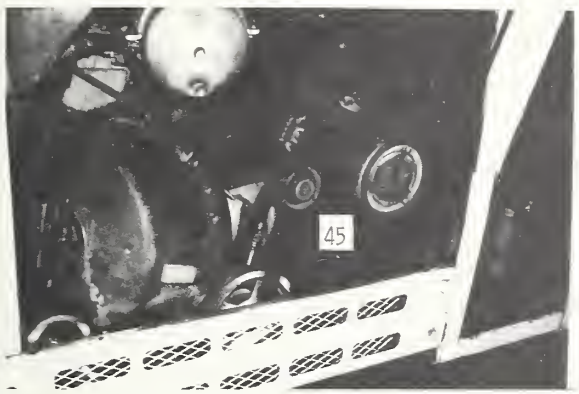
Los Angeles SCRTD
Procedures for AMG-10240B
A/C Modifications

Mod. #1	Mod. #2	Mod. (Final)	Step No.	
		X	45.	Remove A/C belt, tensioning air cylinder, compressor, and mounting base. Cap the tensioning air cylinder air supply line.
X	X		46.	Reinstall (rebuilt) OEM compressor, mounting base and tensioning air cylinder.
		X	47.	Install new A/C compressor mount. (Thermo-King)
		X	48.	Install compressor, clutch, pulley, coil and lines.
X	X	X	49.	Install air conditioning voltage regulator and #901 relay in receiver compartment. Connect wire harness to alternator and regulator.
X	X	X	50.	Install and silver solder engine bulkhead plumbing. Install flex-line from GM fitting #2063113 to compressor manifold; change filter-dryer and install compressor and alternator belts.
X	X	X	51.	Evacuate and charge air conditioning system. Carefully check all joints and fittings for leaks.
X	X	X	52.	Recheck fan hub and fan mounting bolts, alternator and alternator mounting bolts. Check all wiring and alternator output (38 volts).
X	X	X	53.	Install engine, transmission and radiator access doors, rear forward-facing seats, engine seat backs and cushions.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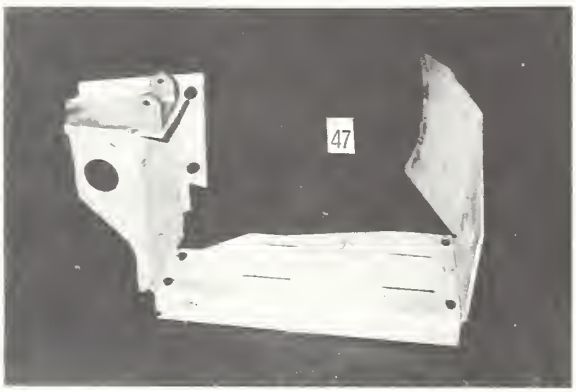
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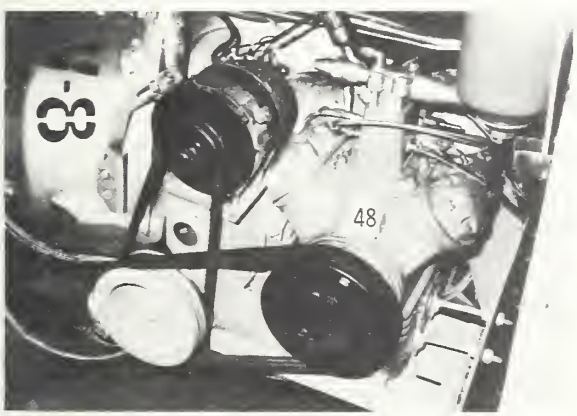
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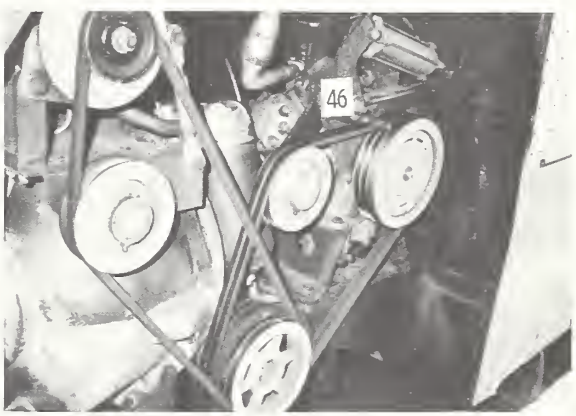
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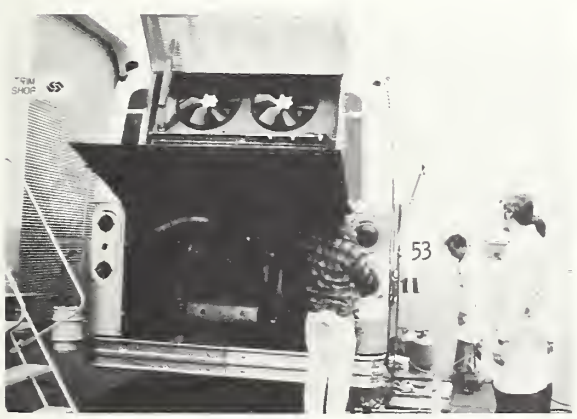
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APPENDIX C

PURCHASED PARTS LISTS

PARTS LIST FOR AMG - 9640B
AIR CONDITIONING MODIFICATION

Mod. #1	Mod. (Final)		
		GRUMMAN FLXIBLE CORP.	
X	X	#70-1885-3	Condenser Fan Motor
X	X	70-1912-21	Condenser Fan Motor Brush Cover
X	X	70-1886-9	Alternator, 36 Volt (Leece Neville #A40014401AE)
X	X	68-609-2	Condenser Fan Assembly
X	X	70-1658-19	Resistor
X	X	70-1886-2	36 Volt Voltage Regulator
X	X	9-1206-22	Alternator Mounting Block
		CARRIER CORP.	
	X	05G	Compressor Kit (6 cyl.)
		TRANE CO.	
X		GB	Compressor (4 cyl.)
		GENERAL MOTORS CORP.	
		RTS-26P-86	Compressor Mounting Parts
X	X	2054277	Support Assembly, Upper (New #2061175)
X	X	2061173	Shaft Cap (4 ea. per bus)
X	X	2054259	Lower Bracket
X		2004573	Rod End Assembly
X		2324040	Turn Buckle Nut
X		2054258	Adjuster Arm
X		2004572	Rod End Assembly
X	X	2436163	Washer
	X	2063228	A/C Discharge Hose (RTS)
	X	2035451	SCR/Fastener Assembly
X	X	790945	5/8 A/C Tubing
X	X	215641	7/8 A/C Tubing
X	X	9421122	A/C Compressor Mounting Bolts
X	X	9425098	Bolt
	X	2004901	Belt, Driver
X	X	2066440	A/C High Pressure (disch.) Switch
X	X	2066501	A/C Low Pressure (suction) Switch

MIAMI METROBUS

PARTS LIST FOR AMG - 9640B
AIR CONDITIONING MODIFICATION

Mod. #1	Mod. (Final)		
		AM GENERAL CORP.	
X	X	#5999153	A/C Dryer
X	X	05962887	Molding
X	X	A5963052	Relay (RY22a)
		BROWNING MFG. DIV.	
X		2BKH60	Sheave, Split Taper H-7/8 Bushing
X		B-71	V-Belt
		OHIO ELECTRIC MTRS.	
X	X	#70-1432-8	Single Sp. Evap. Blower Motor
		LOCAL SUPPLIERS	
X	X	1 1/2" x 3/4	Diamond Flat Expanded Metal
X		Misc. Sheet Alumunum	
X		1/2" Marine Plywood, Rugging	
X		Misc. Angle Iron	
		ITEMS FABRICATED BY METROBUS	
	X	#F1 to F8 Fiberglass Parts (duct work, partition, etc.)	
	X	#M1A to M20B Metal Parts (frames, supports, etc.)	

MIAMI METROBUS
AM GENERAL RETROFIT PARTS LIST
Fiberglass Items - Dimensions

METROBUS PART NUMBER	
F1	Interior Partition with Access Door-88" x 48"
F2	Interior Partition Access Door-31" x 23"
F3, F4	Fan Shroud-front & rear sections (assembled)—Top Opening 52" x 13"; Vertical Measurement at Center Line-33"; Bottom Opening-30" x 8"; Access Door-29" x 21"
F5	Fan Shroud Access Door-29" x 21"
F6	Exterior Louver Panel- 70" x 40"
F7	Condenser Fan Shroud—Rear Opening-41-1/2" x 37"; Depth of Throat-20", Circular Opening-26" dia.
F8	Condensation Drip Pan-49" x 6" x 2" deep

Metal Items

METROBUS PART NUMBER	
M1A	Condenser Fan Motor Support Leg, Left
M1B	Condenser Fan Motor Support Leg, Right
M2	Condenser Fan Shroud Frame, 3 pieces
M3	Condenser Fan Motor Support Leg Spreader
M4	Condenser Fan Motor Mount
M5	Condenser Mount, left side (2 needed per bus)
M6	Top Frame Member Weld Angle (2 needed per bus)
M7	Condenser Mount, Right Side (2needed per bus)
M8	A/C Line Attaching Bracket
M9	Transmission Shift Cable Bracket
M10	Alternator Support Arm
M11	A/C Compressor Mount Support Leg
M12	Main Support Member, Upper
M13	Vertical Side Support, Channel (2 needed per bus)
M14	Frame Base, Angle (2 needed per bus)
M15	Air Intake Grill Frame
M16	Radiator Baffle Box, Aluminum
M17	Exterior Panel Left, Aluminum
M18	Exterior Panel Right, Aluminum
M19	Exterior Panel Bottom, Aluminum
M20A	Interior Partition Base Attaching Angle, Steel
M20B	Interior Partition Base Attaching Angle, Aluminum

Metal Items - Materials, Dimensions

METROBUS PART NUMBER	
M1A & M1B	Legs - 1-1/4" x .125" square tube 20" long Feet - 3" x 2" x 1/4" angle Top Support - 2-1/2" x 1-1/2" x 3/16" angle Center Brace - 2-1/2" x 1-1/2" x 3/16" angle
M2	1" x 1" x 3/16" angle - Box dimensions (41" x 38") Stub pieces - 1" x 3/16", 7" long
M3	1-1/4" x .125" square tube 20-1/2" long Ends - 1-1/2" x 1-1/2" x 3/16" angle
M4	Assembled from 1/4" plate and 2-1/2" x 1-1/2" x 3/16" angle
M5	Assembled from 3/16" steel plate 4-1/2" x 3-1/2" x 3/16" (2 needed per bus)
M6	3" x 2" x 1/4" angle (2 needed per bus)
M7	2-1/2" x 1-1/2" x 3/16" angle (2 needed per bus)
M8	Bent from 3/16" flat bar 5" long 1-1/4" wide
M9	Bent from 3/16" flat bar 3" long 1-1/4" wide
M10	Cut from 3/16" flat bar 15" long
M11	Flat bar 1/4" x 1-1/2" x 12"
M12	3" x 2" x 1/4" angle 66-3/4" long
M13	3" x 1-1/2" x 3/16" channel 38-1/4" long (2 needed per bus)
M14	3" x 2" x 3/16" angle 30-1/2" long (2 needed per bus)
M15	Assembled from 1" x 1" x 3/16" angle dimensions 52" L x 14-1/2" W
M16	Assembled from .063 aluminum 42" x 35" x 8" deep
M17	Cut from .063" aluminum 33" x 9-1/2"
M18	Cut from .063" aluminum 33" x 9-1/2" with inspection door 10" x 6 1/2"
M19	Cut from .063" aluminum 53" long 4-3/4 wide with 1" lip
M20A	1" c 1" x 3/16" angle 47" long drilled as sample
M20B	Cut from .063" aluminum 48" x 2" angle drilled as sample

LOS ANGELES - SCRTD

PARTS LIST FOR AMG - 10240B
AIR CONDITIONING MODIFICATION

Mod. #1	Mod. #2	Mod. (Final)		
			GRUMMAN FLXIBLE CORP.	
		X	480-71-2	or 668097 (G.M.) Mount, A/C Alt.
		X	68-780-1	Condenser-102"
X	X		68-655-2	Condenser-96"
		X	70-1886-7	or A0014401-AD (Leece-Neville) 38V Alt.
X	X	X	461-30-3	or D48-1317X7580 (Ohio) Cond. Fan Mtr.
X	X	X	70-1886-2	or 5065RE (Leece-Neville) Regulator
X	X		96-2286-0001	Alternator Pulley
X	X	X	70-1790-1	or 1115901 (Delco) Relay
X	X		97-2245-1	Fan Blades (14" dia.)
X	X		0460-0628-001	Fan Spacers
X	X		0461-0097-001	Fan Hubs
X	X		0480-0070-001	Pulley, Idler
X	X		0480-0019-002	Turn Buckle
X	X		97-2294-0001	Rod End
X	X		97-2294-0002	Rod End
X	X		97-2357-1	Nut, PTO Shaft
			AM GENERAL CORP.	
X	X		5974479	Idler Sheave Assy.
X	X		5974115	Rubber A/C Mounts
X	X		5974493	Belt Tensioner Cyl.
X	X		5873620	AMG PTO Pulley
X	X		5974351	Drive Belts
X	X	X	5960744	Dryer
			GENERAL MOTORS CORP.	
		X	2074887	Hub, Cond. Fan (Bus-188 TRANE)
		X	2074888	Fan, Cond. (Fan-1016 TRANE)
		X	2074889	Panel, Orif. (ORF-161 TRANE)
X	X		1508844	55 LB. Switch
X	X		793355	25 LB. Switch (oil press.)
X	X		2463512	Discharge Manifold
			THERMO-KING CORP.	
		X	710578	A/C Compressor Kit
			TRANE CO.	
X	X		GB	Compressor

LOS ANGELES - SCRTD

PARTS LIST FOR AMG - 10240B
AIR CONDITIONING MODIFICATION

Mod. #1	Mod. #2	Mod. (Final)	ITEMS FABRICATED BY SCRTD
X	X		Drain Pan
X	X		Air Box Assy.
		X	Condenser Motor Brackets
X	X		Alternator Mounting/Idler Pulley Bracket
X	X		Louvered Panel Body Skin
X	X		Condenser Door
X	X	X	Bulkhead Assy.
X	X	X	Bulkhead Frame
X	X	X	12 1/2" #20 Flex Line
X	X	X	"Hi-Lo" Flex Lines
		X	Steel Plenum Chamber
		X	Louvered Access Door
		X	Removeable Condenser Grill
		X	A/C Compartment Grill Door

MISCELLANEOUS ITEMS AS REQUIRED

7/8 O.D. Copper Pipe (.045 Wall)
1-1/8 O.D. Copper Pipe
7/8" 45° elbow
1-1/8" 45° elbow
7/8" 90° elbow
1-1/8" 90° elbow
7/8" - 5/8" Reducer
7/8" Union
1-1/8" Union
Adapter, Suction Hose (G.M.)
#20 Clamps
#6 Clamps
#16 Clamps
#26 Grommets
#68 Grommets
Discharge Gasket 25-822-25
Suction Gasket 25-822-26
Misc. Nuts, Bolts,
Screws, Wire, Paint,
Tape, etc.

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