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Kelm et al.

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(54) **HYBRID ELECTRIC/MECHANICAL COMPRESSOR WITH GEAR REDUCER**

(75) Inventors: **Brian Robert Kelm**, Northville, MI (US); **Robert John Mohrmann**, Pinckney, MI (US); **Richard Eric Luken**, Farmington Hills, MI (US); **Stephen Kempfer**, Canton, MI (US); **Shawn Harold Swales**, Canton, MI (US)

(73) Assignee: **Visteon Global Technologies, Inc.**, Dearborn, MI (US)

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(51) **Int. Cl.**[7] **F04B 49/00**; B60K 1/00; B60K 41/02

(52) **U.S. Cl.** **417/212**; 417/410.1; 417/374; 180/65.2; 477/5; 62/157

(58) **Field of Search** 417/212, 269, 417/415, 410.1, 222.2, 374; 62/157; 180/65.2; 477/5

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,725,825 A		12/1955	Cibattari	417/120
2,888,810 A		6/1959	Hann	62/215
2,902,205 A		9/1959	Parker	417/319
3,861,484 A	*	1/1975	Joslin	180/65.2
5,275,011 A	*	1/1994	Hanson et al.	62/157
5,772,407 A	*	6/1998	Kato et al.	417/269
6,176,808 B1	*	1/2001	Brown et al.	477/5
6,234,769 B1	*	5/2001	Sakai et al.	417/374
6,443,712 B2	*	9/2002	Sakai et al.	417/374
6,494,277 B1	*	12/2002	Boggs et al.	180/65.2

FOREIGN PATENT DOCUMENTS

JP 11-287182 * 10/1999

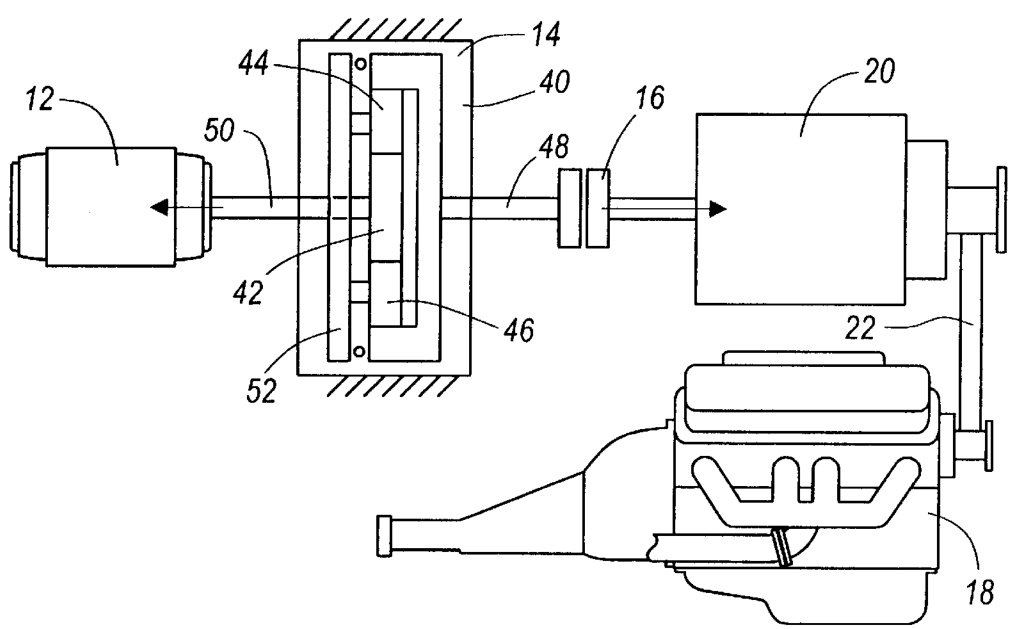
* cited by examiner

Primary Examiner—Cheryl J. Tyler
Assistant Examiner—Michael K. Gray
(74) *Attorney, Agent, or Firm*—Brinks Hofer Gilson & Lione

(57) **ABSTRACT**

A system for driving a compressor is disclosed. The system includes an internal combustion engine in communication with the compressor for selectively driving an input shaft of the compressor; an electric motor in communication with the compressor for selectively driving the compressor when the compressor is not being driven by the engine; and a gear assembly operatively connected to a motor output of the electric motor shaft for changing a rotational speed of the motor output shaft.

19 Claims, 2 Drawing Sheets



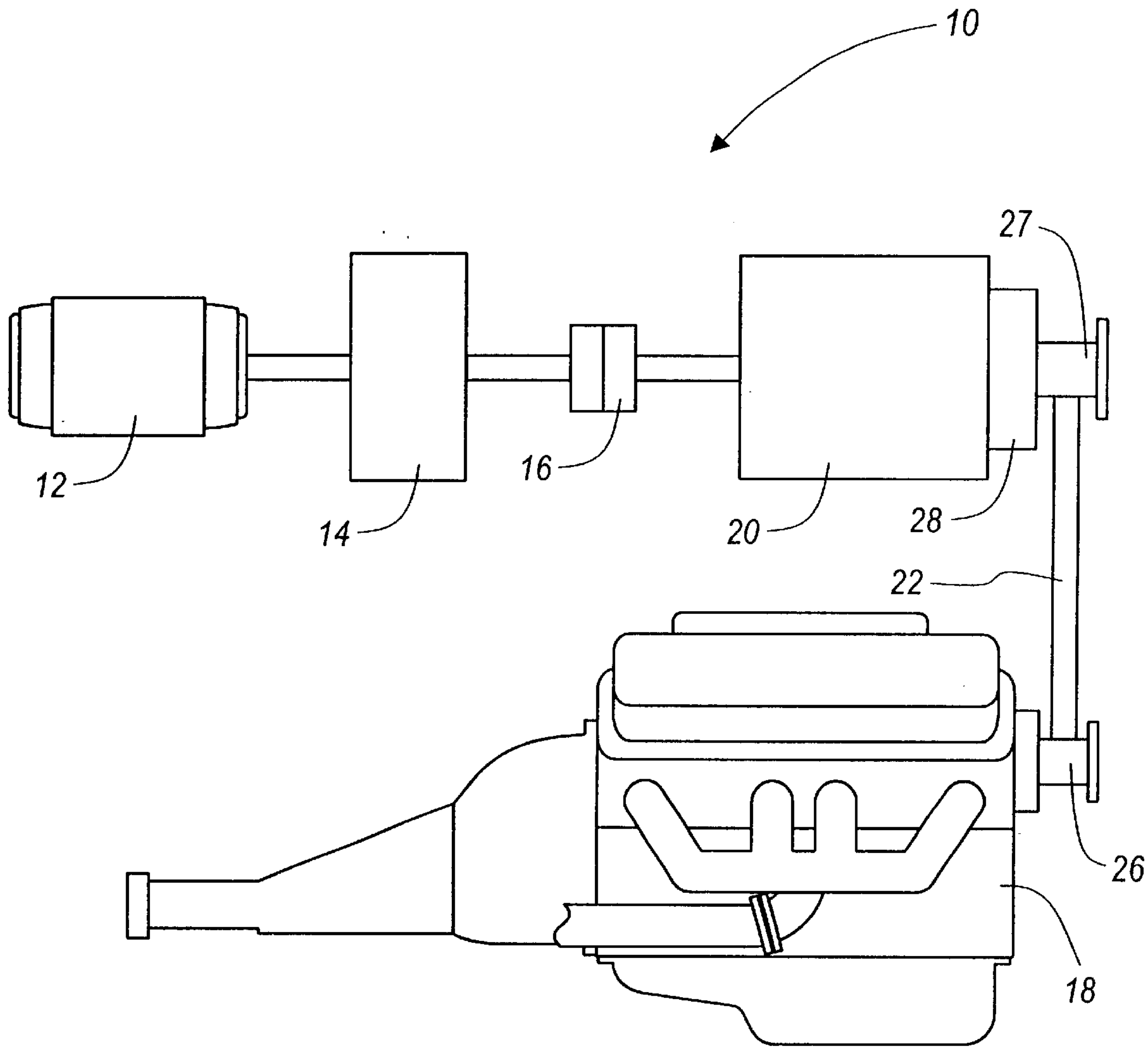


FIG. - 1

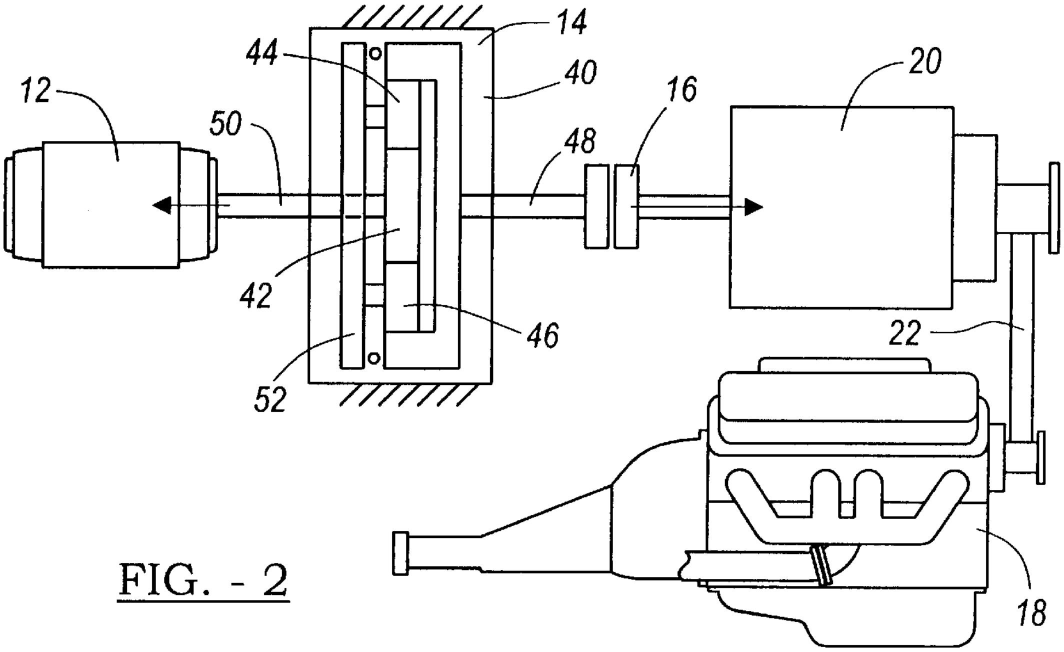


FIG. - 2

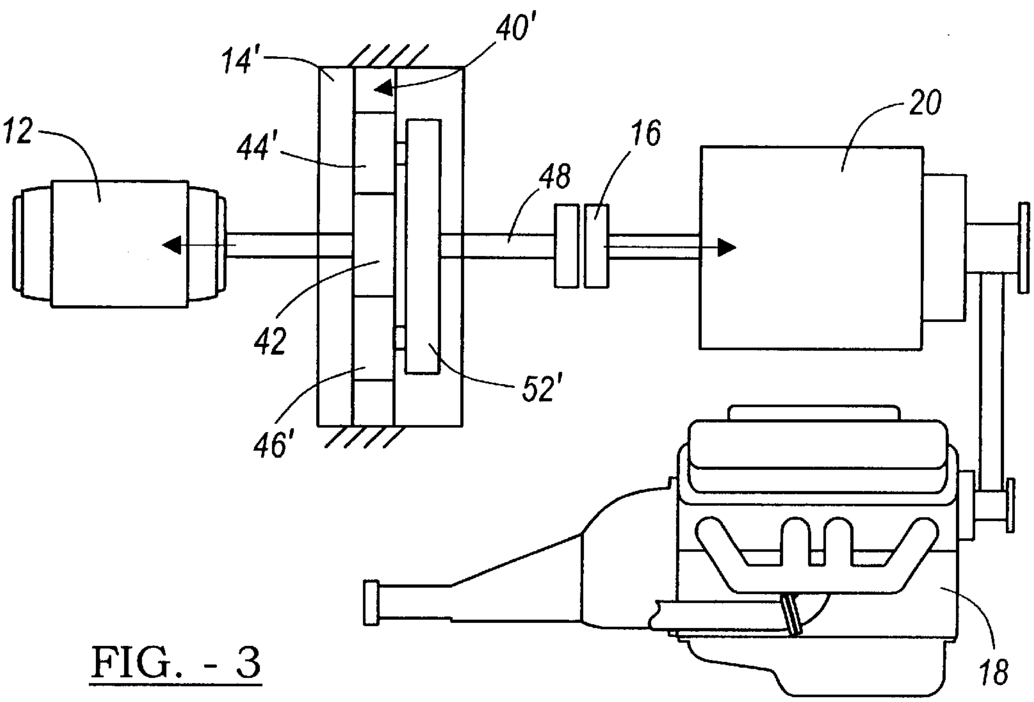


FIG. - 3

HYBRID ELECTRIC/MECHANICAL COMPRESSOR WITH GEAR REDUCER

BACKGROUND OF THE INVENTION

The present invention relates to AC compressors and systems and methods for driving the AC compressor using an electric motor and an internal combustion engine.

BACKGROUND ART

Hybrid compressor systems having an electric motor and an internal combustion engine coupled to an AC compressor have gained widespread interest, especially in the automotive environment. Typically, an AC compressor is driven by an automobile's engine during engine operation. When the engine is not operating, an electric motor is used to drive the compressor. Generally, the engine is coupled to the compressor through a drive belt and clutch mechanism. The electric motor, however, is typically coupled to the AC compressor via a solid shaft.

While conventional systems for driving AC compressors achieve their intended purpose, many problems still exist. For example, while the engine is operating and therefore driving the AC compressor, the electric motor being attached to the AC compressor through a solid shaft is also turning. The rotation of the electric motor while the AC compressor is driven by the engine not only decreases efficiency of the overall system by adding additional load on the engine but also increases wear of the electric motor.

Other problems not resolved by the prior art include having to choose from a limited selection of electric motors having a desired torque output to drive the AC compressor. Disadvantageously, the electric motor needed to develop the required torque is costly and adds significant weight to the vehicle.

Therefore, what is needed is a new and improved system and method for driving an AC compressor. The new and improved system and method must increase the efficiency of the overall system and reduce wear. Moreover, the new and improved system and method must reduce the torque requirements of the electric motor, thereby reducing cost and weight of the overall system.

BRIEF SUMMARY OF THE INVENTION

In accordance with an aspect of the present invention, a new and improved system and method for driving an AC compressor is provided. The system and method of the present invention eliminates the problems stated above by introducing a clutch mechanism between an electric motor and an AC compressor.

In accordance with another aspect of the present invention, a system for driving a compressor is provided. The system has an internal combustion engine in communication with the compressor for selectively driving an input shaft of the compressor, an electric motor in communication with the compressor for selectively driving the compressor when the compressor is not being driven by the engine, and a gear assembly operatively connected to a motor output of the electric motor shaft for changing a rotational speed of the motor output shaft.

In accordance with another aspect of the present invention, further having a clutch positioned between the gear assembly and the compressor for decoupling the compressor from the motor when the engine is driving the compressor.

In accordance with yet another aspect of the present invention, the clutch is a one-way clutch.

In accordance with yet another aspect of the present invention, the clutch is an electric clutch.

In accordance with yet another aspect of the present invention, the gear assembly further comprises a sun gear and a planetary gear.

In accordance with yet another aspect of the present invention, the sun gear is fixed to the motor output shaft.

In accordance with yet another aspect of the present invention, the gear assembly further includes a planetary gear carrier.

In accordance with yet another aspect of the present invention, the planetary gear is rotatably fixed to the carrier.

In accordance with yet another aspect of the present invention, the carrier is fixed to a stationary gear case that houses the gear assembly.

In accordance with yet another aspect of the present invention, a ring gear wherein the ring gear is fixed to the compressor input shaft.

In accordance with yet another aspect of the present invention, the carrier is configured for slideable engagement with the ring gear.

In accordance with yet another aspect of the present invention, a system for driving a compressor is provided. The system has an internal combustion engine, an electric motor, a gear assembly, and a clutch. The internal combustion engine is in communication with a compressor for selectively driving an input shaft of the compressor. The electric motor is in communication with the compressor for selectively driving the compressor when the compressor is not being driven by the engine. The gear assembly is operatively connected to a motor output shaft of the electric motor for changing a rotational speed of the motor output shaft. The clutch is positioned between the gear assembly and the compressor for decoupling the compressor from the motor when the engine is driving the compressor.

Further objects, features and advantages of the invention will become apparent from consideration of the following description and the appended claims when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a AC compressor drive system for selectively driving an AC compressor with an electric motor and an internal combustion engine, in accordance with the present invention;

FIG. **2** is a schematic diagram of a preferred embodiment of a system for driving an AC compressor, in accordance with the present invention; and

FIG. **3** is a schematic diagram of another embodiment of a system for driving an AC compressor, in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. **1**, a schematic diagram of a AC compressor drive system **10** for powering a compressor is illustrated, in accordance with the present invention. Compressor drive system **10** includes an electric motor **12**, a gear box **14**, an electric motor clutch mechanism **16**, and an engine **18**. Electric motor **12** and engine **18** selectively drive a compressor **20**.

For example, when engine **18** is not operating, electric motor **12** drives compressor **20**. However, when the engine **18** is operating, the engine drives compressor **20**.

Electric motor **12** is coupled to compressor **20** through gear box **14** and clutch **16**. The specific features and components of gear box **14** will be described hereinafter. Gear box **14** allows a wider varieties of electric motors to be used to drive AC compressor **20** by reducing the torque output requirements that electric motor **12** must deliver to compressor **20**. Electric motor clutch **16** allows the electric motor **12** to be selectively engaged or disengaged to compressor **20**.

Engine **18** is coupled to compressor **20** through a drive belt **22** and a motor pulley **26** and a compressor pulley **27**. When the engine is not driving compressor **20**, an engine clutch mechanism **28** disengages the drive belt **22** and thus engine **18** from compressor **20**.

Accordingly, the present invention reduces load on the engine by disengaging the electric motor **12** when the engine **18** is driving the compressor **20** and therefore increases the efficiency of system **10**.

Referring now to FIG. **2**, a preferred embodiment of system **10** is further illustrated, in accordance with the present invention. Gear box **14** includes a ring gear **40**, a sun gear **42** and a pair of planetary gears **44** and **46**. Ring gear **40** is coupled to clutch mechanism **16** via a solid shaft **48**, while sun gear **42** is coupled to electric motor **12** via a solid shaft **50**. Planetary gears **44** and **46** are rotatably attached to a carrier **52** that is in turn fixedly attached to shaft **50**. Alternatively, more than 2 planetary gears may be used, for example 3 planetary gears my be utilized in an embodiment of the present invention.

Gear mechanism **14** allows various motors to be selected to operate at different speeds to produce the required power output. More specifically, a motor having a reduced torque output may be used by amplifying the speed of motor output with an appropriate gear arrangement. For example, the gear mechanism shown in FIG. **2** may be operated to amplify or reduce the compressor input by rotating the carrier and thus the planetary gears about the sun gear **42** and fixing the carrier to the case. Further, gear mechanism **14** may be operated to rotate the compressor input shaft at the same rate of rotation of the motor output shaft by fixing the carrier **52** to the ring gear **40**.

Referring now to FIG. **3**, another embodiment of the present invention is illustrated. The compressor drive system of FIG. **3** includes a gear mechanism **14'** having a fixed ring gear **40'** and a carrier **52'** fixed to the compressor input shaft **48**. Carrier **52'** has two planetary gears **44'** and **46'** rotatably attached thereto. In an alternate embodiment of the present invention more than two planetary gears may be used, for example three planetary gears may be used. The gear arrangement in FIG. **3**, allows the motor to operate with a lower torque requirement at a higher speed and deliver the same power to the compressor than a motor operating at a lower speed and higher torque, powering the compressor directly.

Accordingly, the present invention has many advantages and benefits of the prior art. For example, the present invention provides a means for selecting a variety of electrical motors to drive the AC compressor in the most cost effective and weight conscious way. Moreover, the present invention provides a means for decoupling the electric motor from the compressor when the engine is operating thereby increasing the overall efficiency of the system and reducing wear on the electric motor **12**.

The foregoing discussion discloses and describes a preferred embodiment of the invention. One skilled in the art will readily recognize from such discussion, and from the

accompanying drawings and claims, that changes and modifications can be made to the invention without departing from the true spirit and fair scope of the invention as defined in the following claims.

What is claimed is:

1. A system for driving a compressor, the system comprising:

an internal combustion engine connected to the compressor for selectively driving an input shaft of the compressor;

an electric motor connected to the compressor for selectively driving the compressor when the compressor is not being driven by the engine;

a gear assembly operatively connected to a motor output shaft of the electric motor and to the input shaft of the compressor for changing a rotational speed of the motor output shaft; and

a clutch positioned between the pear assembly and the compressor for decoupling the compressor from the motor when the engine is driving the compressor.

2. The system of claim **1** wherein the clutch is a one-way clutch.

3. The system of claim **1** wherein the clutch is an electric clutch.

4. The system of claim **1** wherein the gear assembly further comprises a sun gear and a planetary gear.

5. The system of claim **4** wherein the sun gear is fixed to the motor output shaft.

6. The system of claim **4** wherein the gear assembly further comprises a planetary gear carrier.

7. The system of claim **6** wherein the planetary gear is rotatably fixed to the carrier.

8. The system of claim **6** wherein the carrier is fixed to a stationary gear case that houses the gear assembly.

9. The system of claim **6** further comprising a ring gear wherein the ring gear is fixed to the compressor input shaft.

10. The system of claim **9** wherein the carrier is configured for slideable engagement with the ring gear.

11. A system for driving a compressor, the system comprising:

an internal combustion engine connected to the compressor for selectively driving an input shaft of the compressor;

an electric motor connected to the compressor for selectively driving the compressor when the compressor is not being driven by the engine;

a means for changing a rotational speed of the motor output shaft operatively connected to a motor output shaft of the electric motor; and

a means for decoupling positioned between the means for changing a rotational speed and the compressor for decoupling the compressor from the motor when the engine is driving the compressor.

12. The system of claim **11** wherein the means for changing a rotational speed of the motor output further comprises a sun gear and a planetary gear.

13. The system of claim **12** wherein the sun gear is fixed to the motor output shaft.

14. The system of claim **12** the means for changing a rotational speed of the motor output further comprises a planetary gear carrier.

15. The system of claim **14** wherein the planetary gear is rotatably fixed to the carrier.

16. The system of claim **14** further comprising a ring gear is fixed to a stationary gear case that houses the means for changing a rotational speed of the motor output.

17. The system of claim **14** further comprising a earner wherein the carrier is fixed to the compressor input shaft.

18. The system of claim **11** wherein the means for decoupling is a one-way clutch.

19. The system of claim **11** wherein the means for decoupling is an electric clutch.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,644,932 B2
DATED : November 11, 2003
INVENTOR(S) : Brian R. Kelm et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 4,
Line 60, after "claim **12**" insert -- wherein --.
Line 66, before "fixed" delete "is".

Column 5,
Line 1, delete "earner" and substitute -- carrier -- in its place.

Signed and Sealed this

Sixteenth Day of March, 2004

JON W. DUDAS
Acting Director of the United States Patent and Trademark Office