PTO/AIA/15 (07-12)
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U.S. Patent and Trademark Office. U.S. DEPARTMENT OF COMMERCE

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	MAG04 P-2029
First Inventor	Kenneth Schofield
Title	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE
Express Mail Label No.	

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. [ ] **Fee Transmittal Form.** (PTO/SB/17 or equivalent)
2. [ ] **Applicant claims small entity status.** See 37 CFR 1.27.
3. [x] **Specification.** [*Total Pages* 58] Both the claims and abstract must start on a new page *(For information on the preferred arrangement, see MPEP § 608.01(a))*
4. [x] **Drawing(s).** (*35 U.S.C. 113*) [*Total Sheets* 13]
5. **Inventor's Oath or Declaration.** [*Total Sheets* 1] *(including substitute statements under 37 CFR 1.64 and assignments serving as an oath or declaration under 37 CFR 1.63(e))*
   a. [ ] Newly executed (original or copy)
   b. [X] A copy from a prior application (37 CFR 1.63(d))
6. [x] **Application Data Sheet.** **See Note below.* See 37 CFR 1.76 (PTO/AIA/14 or equivalent)
7. [ ] **CD-ROM or CD-R.** in duplicate, large table or Computer Program *(Appendix)*
   [ ] Landscape Table on CD
8. **Nucleotide and/or Amino Acid Sequence Submission.** *(if applicable, items a. – c. are required)*
   a. [ ] Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. [ ] CD-ROM or CD-R (2 copies); or
      ii. [ ] Paper
   c. [ ] Statements verifying identity of above copies

ADDRESS TO:

Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

ACCOMPANYING APPLICATION PARTS

9. [ ] **Assignment Papers.** (cover sheet & document(s))
   Name of Assignee_____
10. [ ] **37 CFR 3.73(c) Statement.** [ ] **Power of Attorney.** *(when there is an assignee)*
11. [ ] **English Translation Document.** *(if applicable)*
12. [ ] **Information Disclosure Statement.** (PTO/SB/08 or PTO-1449)
    [ ] Copies of citations attached
13. [ ] **Preliminary Amendment.**
14. [ ] **Return Receipt Postcard.** *(MPEP § 503) (Should be specifically itemized)*
15. [ ] **Certified Copy of Priority Document(s).** *(if foreign priority is claimed)*
16. [ ] **Nonpublication Request.** Under 35 U.S.C. 122(b)(2)(B)(i). Applicant must attach form PTO/SB/35 or equivalent.
17. [ ] **Other:**_____

19. CORRESPONDENCE ADDRESS

[■] The address associated with Customer Number: 15671 **OR** [ ] Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone		Email	

Signature	/taf/		Date	March 13, 2013	
Name (Print/Type)	Timothy A. Flory			Registration No. (Attorney/Agent)	42540

PATENT
MAG04 P-2059

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventors : Kenneth Schofield, Mark L. Larson and Keith J. Vadas

For : MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir or Madam:

REQUEST FOR FILING CONTINUATION APPLICATION

UNDER 37 CFR 1.53(b)

This is a request for filing a continuation of U.S. patent application Serial No. 12/688,146, filed January 15, 2010, which is a continuation of U.S. patent application Serial No. 12/496,357, filed July 1, 2009, which is a continuation of U.S. patent application Serial No. 11/122,880, filed May 5, 2005, now U.S. Patent No. 7,561,181, which is a continuation of U.S. patent application Ser. No. 10/324,679, filed on December 20, 2002, now U.S. Patent No. 6,891,563, which is a continuation of U.S. patent application Ser. No. 08/952,026, filed under 35 U.S.C. § 371 on November 19, 1997, now U.S. Patent No. 6,498,620, which is based on International Patent Application No. PCT/US96/07382, filed May 22, 1996.

1. Copy of Prior Application as Filed Which is Attached

I hereby verify that the attached papers are a copy of what is shown in my records to be the above-identified prior application, including the Declaration as originally filed (37 CFR 1.53). No amendments referred to in any Declaration filed to complete the prior application introduced new matter in that application.

The attached copy of the papers of the parent application includes 34 pages of specification, 23 pages of claims (86 claims), 1 page of Abstract, 13 sheets of drawings, and signed Declaration and Power of Attorney (3 pages). The attached drawings are copies of the formal drawings filed in the parent application and correspond to the drawings originally filed with the parent application and as amended and/or approved during prosecution of the parent application.

2. Amendments

The copy of the application includes any amendments made during prosecution of the parent applications and includes a revised/updated Cross Reference to Related Applications and new Abstract.

The application includes new claims 1-86, which replace the claims of the parent application.

3. Notice Regarding Prosecution relative to Parent Application

This application is a continuation of U.S. patent application Serial No. 12/688,146, filed January 15, 2010, which is part of the continuation chain noted above. Applicant notes from controlling case law that disclaimer of subject matter made during an earlier prosecution can be rescinded, permitting recapture of the disclaimed scope, so long as sufficiently clear notice is given to the U.S. Patent and Trademark Office, so that the U.S. Patent and Trademark Office can consider any prior disclaimer and any previously cited relevant prior art *Hakim v. Cannon Avent Group, PLC et al.*, 47 F.3d 1313, 1398 (Fed. Cir. 2007) (affirming the district court grant of summary judgment of non-infringement based on a limiting claim construction per file wrapper estoppel in a

parent application where the patentee had in the child application not expressly rescinded any disclaimer effect of prosecution in the parent application).

Therefore, this is to provide such clear notice to the U.S. Patent and Trademark Office that for purposes of the present application only, Applicant hereby rescinds any disclaimer and argument, express or implied, made during the prosecution of the above-referenced prior application. Accordingly, Applicant respectfully notes for the record that any arguments, disclaimers, and/or other actions taken with regard to the claims prosecuted in the above-referenced U.S. Patent Applications are not to be imputed or otherwise applied to the claims in the present application unless expressly repeated by the Applicant during prosecution of the present application.

4. Patent Application Bibliographic Data Form

A copy of the Patent Application Bibliographic Data Form is enclosed.

5. Filing Fee and Calculation

Filing Fee:	
Basic Fee - $390	$390.00
Each independent claim in excess of three, -1- times $250.00	$250.00
Number of claims in excess of twenty, -66- times $62.00	$4,092.00
Filing multiple dependent claims per application $460.00	$.00
Application size fee for each additional 50 sheets that exceeds 100 sheets (-0- times $320.00)	$0.00

Additional Fees:	
Search Fee - $620	$620.00
Examination Fee - $250	$250.00
Total Filing Fee	**$5,602.00**

The above fees will be paid by credit card. The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment, to Deposit Account No. 50-5553.

The Commissioner is hereby authorized to charge the following fees during the pendency of this application, or credit any overpayment to Deposit Account 50-5553.

a) Any filing fees under 37 CFR 1.16 for presentation of extra claims for which full payment has not been tendered.

b) Any patent application processing fees under 37 CFR 1.17 for which full payment has not been tendered.

6. Drawings

Thirteen (13) sheets of formal drawings are enclosed and are copies of those filed in the parent application. The formal drawings correspond to the drawings originally filed with the parent application and include any revisions made and approved during prosecution of the parent application.

7. Disclosure Statement

Applicants respectfully request that information cited in the prior parent application, Serial No. 12/688,146, be considered in the present application. An Information Disclosure Statement will be submitted that lists the cited references.

8. Inventorship Statement

With respect to the prior U.S. application from which this application claims benefit under 35 USC 120, the inventors in this application are the same, namely, Kenneth Schofield, Mark L. Larson and Keith J. Vadas.

9. Assignment

The prior application is assigned to Donnelly Corporation, a corporation of the State of Michigan, located and doing business at 414 East Fortieth Street, Holland, Michigan 49423. That Assignment was recorded in the United States Patent and Trademark Office on November 19, 1997, at Reel 9056, Frame 0917.

10. Power of Attorney

The Power of Attorney in the parent applications is to the individual patent attorneys listed thereon. The attached Power of Attorney includes the original declaration signed by the inventors and confirms that the undersigned attorney is an attorney of record for this application.

Please address all future correspondence to:

Timothy A. Flory
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Drive, S.E.
Grand Rapids, MI 49588-8695
Ph: (616) 975-5500
Fax: (616) 975-5505

11. Verification

I hereby declare further that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Respectfully submitted,

Date: March 13, 2013

Timothy A. Flory
Registration No. 42 540
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Drive, S.E., Suite 207
Grand Rapids, Michigan 49588-8695
(616) 975-5500

TAF/ars
MAG04 P-2059

PTO/AIA/14 (08-12)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MAG04 P-2059
	Application Number	
Title of Invention	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Kenneth		Schofield	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Holland	State/Province	MI	Country of Residence i	US

Mailing Address of Inventor:

Address 1	4793 Crestridge Court		
Address 2			
City	Holland	State/Province	MI
Postal Code	49423	Country i	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Mark	L.	Larson	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Grand Haven	State/Province	MI	Country of Residence i	US

Mailing Address of Inventor:

Address 1	10500 Stump Street		
Address 2			
City	Grand Haven	State/Province	MI
Postal Code	49417	Country i	US

Inventor 3 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Keith	J.	Vadas	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

PTO/AIA/14 (08-12)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MAG04 P-2059
	Application Number	
Title of Invention	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE	

City	Coopersville	State/Province	MI	Country of Residence i	US

Mailing Address of Inventor:

Address 1	552 Harrison Avenue		
Address 2			
City	Coopersville	State/Province	MI
Postal Code	49404	Country i	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	15671		
Email Address	flory@glbf.com	Add Email	Remove Email

Application Information:

Title of the Invention	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE		
Attorney Docket Number	MAG04 P-2059	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	13	Suggested Figure for Publication (if any)	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MAG04 P-2059
	Application Number	
Title of Invention	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE	

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	15671		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	12688146	2010-01-15
Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
12688146	Continuation of	12496357	2009-07-01
Prior Application Status	Patented		Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12496357	Continuation of	11122880	2005-05-05	7561181	2009-07-14
Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
11122880	Continuation of	10324679	2002-12-20	6891563	2005-05-10
Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
10324679	Continuation of	08952026	1997-11-19	6498620	2002-12-24

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
08952026	a 371 of international	PCT/US1996/07382	1996-05-22

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country [i]	Filing Date (YYYY-MM-DD)	Priority Claimed
			○ Yes ◉ No

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MAG04 P-2059
	Application Number	
Title of Invention	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE	

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Authorization to Permit Access:

☐ Authorization to Permit Access to the Instant Application by the Participating Offices

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

PTO/AIA/14 (08-12)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MAG04 P-2059
	Application Number	
Title of Invention	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE	

Organization Name	Donnelly Corporation		
Mailing Address Information:			
Address 1	49 W. Third Street		
Address 2			
City	Holland	**State/Province**	MI
Country i US		Postal Code	49423
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section only if non-applicant assignee information is desired to be included on the patent application publication in accordance with 37 CFR 1.215(b). Do not include in this section an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest), as the patent application publication will include the name of the applicant(s).

Remove

If the Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information:			
Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee Data may be generated within this form by selecting the Add button. Add

PTO/AIA/14 (08-12)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	MAG04 P-2059
	Application Number	
Title of Invention	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE	

Signature:

Remove

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications

Signature	/taf/			Date (YYYY-MM-DD)	2013-03-13
First Name	Timothy	Last Name	Flory	Registration Number	42540

Additional Signature may be generated within this form by selecting the Add button. Add

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Please type a plus sign (+) inside this box → [+]

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Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION

☐ Declaration Submitted with Initial Filing OR ☐ Declaration Submitted after Initial Filing

Attorney Docket Number	DON01 P-612
First Named Inventor	Kenneth (NMI) Schofield
COMPLETE IF KNOWN	
Application Number	
Filing Date	
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled :

REARVIEW VISION SYSTEM FOR VEHICLE INCLUDING PANORAMIC VIEW

(Title of the Invention)

the specification of which

☐ is attached hereto

OR

☒ was filed on (MM/DD/YYYY) 05/22/1996 as United States Application Number or PCT International

Application Number PCT/US96/07382 and was amended on (MM/DD/YYYY) 06/03/1997 (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37 Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35 United States Code §119 (a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365 (a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority sheet attached hereto:

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	
		☐ Additional provisional application numbers are listed on a supplemental priority sheet attached hereto.

Burden Hour Statement: This form is estimated to take 0.4 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner of Patents and Trademarks, Washington, DC 20231.

(January 1997)

Please type a plus sign (+) inside this box → [+]

PTO/SB/01 (8-96)
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DECLARATION

I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s), or §365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application Number	PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)
08/445,527		05/22/1995	5,670,935

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority sheet attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

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DECLARATION

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☐ Additional inventors are being named on supplemental sheet(s) attached hereto

MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 12/688,146, filed Jan. 15, 2010 (Attorney Docket MAG04 P-1585), which is a continuation of U.S. patent application Ser. No. 12/496,357, filed Jul. 1, 2009 (Attorney Docket MAG04 P-1536), which is a continuation of U.S. patent application Ser. No. 11/122,880, filed May 5, 2005, now U.S. Pat. No. 7,561,181, which is a continuation of U.S. patent application Ser. No. 10/324,679, filed on Dec. 20, 2002, now U.S. Pat. No. 6,891,563, which is a continuation of U.S. patent application Ser. No. 08/952,026, filed under 35 U.S.C. § 371, filed Nov. 19, 1997, now U.S. Pat. No. 6,498,620, which is based on International Patent Application No. PCT/US96/07382, filed May 22, 1996.

BACKGROUND OF THE INVENTION

[0002] This invention relates generally to vision systems for vehicles and, more particularly, to rearview vision systems which provide the vehicle operator with scenic information in the direction rearward of the vehicle. More particularly, the invention relates to a rearview vision system utilizing image capture devices, such as CMOS imaging arrays and the like.

[0003] A long-felt need in the art of vehicle rearview vision systems is to reduce the amount of time spent gathering information of the condition around the vehicle in order to safely carry out a vehicle maneuver, such as a turn or a lane change. It has been determined that up to about 50 percent of maneuver time is spent gathering information with conventional rearview mirrors. This typically requires viewing one or more mirrors, turning the head and body to check blind spots, and double-checking the mirrors prior to executing the maneuver. Some improvement has been obtained by adjusting mirror optics, for example, to increase the observed field of view rearward of the vehicle. However, this is achieved with an increase in image distortion which makes driver awareness of conditions to the side and rear of the vehicle even more difficult.

[0004] Another long-felt need in the art of vehicle rearview vision systems has been to eliminate exterior rearview mirrors by utilizing image capture devices, such as cameras, in combination with dashboard displays. This would be beneficial because it would reduce

wind drag on the vehicle, wind noise and vehicle weight. Furthermore, rearview mirrors protrude a substantial distance from the side of the vehicle, which makes maneuvering in tight spaces more difficult. Image capture devices are capable of positioning in a greater variety of locations on the vehicle, providing more flexibility of vehicle styling. It is further expected that camera systems would greatly reduce the blind spots to the sides and rear of the vehicle common with vehicles equipped with conventional rearview mirror systems. The driver cannot perceive vehicles, objects, or other road users in such blind spots without turning his or her body, which interferes with forward-looking visual activities.

[0005] Camera-based rearview vision systems for vehicles have not obtained commercial acceptance. One difficulty with proposed systems has been that they present a large amount of visual information in a manner which is difficult to comprehend. This difficulty arises from many factors. In order to significantly reduce blind spots, multiple image capture devices are typically positioned at various locations on the vehicle. The image of an object behind the equipped vehicle is usually captured by more than one image capture device at a time and displayed in multiple images. This may confuse the driver as to whether more than one object is present. When multiple image capture devices are positioned at different longitudinal locations on the vehicle, objects behind the vehicle are at different distances from the image capture devices. This results in different image sizes for the same object. This effect is especially noticeable for laterally extending images, such as a bridge, highway crosswalk markings, the earth's horizon, and the like. Such images are at different vertical angles with respect to the image capture devices. This results in different vertical positions on the display causing the elongated image to appear disjointed.

[0006] A camera system provides a monocular view of the scene, compared to the binocular stereoscopic view obtained when the scene is viewed through a rearview mirror. This makes the ability to judge distances in a camera system a problem. This effect is most noticeable at distances close to the vehicle where stereoscopic imaging is relied upon extensively by the driver in judging relative locations of objects. Therefore, known camera systems fail to provide to the driver important information where that information is most needed at small separation distances from surrounding objects.

[0007] Another difficulty with camera systems is that, in order to provide a sufficient amount of information, the camera system typically presents the driver with a greatly

increased field of view. This improves performance by further reducing blind spots at the side and rear of the vehicle. However, an increased field of view is often obtained by utilizing a wide-angle lens which introduces distortion of the scene and further impairs the ability of the driver to judge distances of objects displayed. The problem with such distortion of the scene is that the driver must concentrate more on the display and take a longer time to interpret and extract the necessary information. This further distracts the driver from the primary visual task of maintaining awareness of vehicles and other objects in the vicinity of the driven vehicle.

[0008] Yet an additional difficulty with camera systems is that flat panel displays present the image captured by the rearward-facing image capture device, or devices, at a focal length that approximates the arm length of the vehicle driver. In order to observe the condition of the vehicle utilizing the rearview vision system, the driver must change his or her gaze from the forward field of view of the vehicle to the display. Because the forward field of view of the vehicle is at a focal length that is much greater than the focal length of the displayed image, the eyes of the driver must refocus upon changing gaze. This refocusing further increases the amount of time for the driver to assimilate the information in the displayed image. Furthermore, when the gaze of the driver returns to the forward field of view, the eyes must, again, refocus to the greatly longer distance.

[0009] Yet an additional difficulty with camera systems is that of finding adequate space in the crowded area of the vehicle's dashboard for the components making up the display.

SUMMARY OF THE INVENTION

[0010] The present invention is directed towards enhancing the interpretation of visual information in a rearview vision system by presenting information in a manner which does not require significant concentration of the driver or present distractions to the driver. This is accomplished according to an aspect of the invention in a rearview vision system having at least two image capture devices positioned on the vehicle and directed generally rearwardly with respect to the direction of travel of the vehicle. A display is provided for images captured by the image capture devices. The display displays an image synthesized from outputs of the image capture devices which approximates a rearward-facing view from a single location. In order to obtain all of the necessary information of activity, not only behind but also along side of the vehicle, the virtual camera should be positioned forward of the driver. The image synthesized from the multiple image capture

devices may have a dead space which corresponds with the area occupied by the vehicle. This dead space is useable by the driver's sense of perspective in judging the location of vehicles behind and along side of the equipped vehicle.

[0011] The present invention provides techniques for synthesizing images captured by individual, spatially separated, image capture devices into such ideal image, displayed on the display device. This may be accomplished, according to an aspect of the invention, by providing at least three image capture devices. At least two of the image capture devices are side image capture devices mounted on opposite sides of the vehicle. At least one of the image capture devices is a center image capture device mounted laterally between the side image capture devices. A display system displays an image synthesized from outputs of the image capture devices. The displayed image includes an image portion from each of the image capture devices. The image portion from the center image capture device is vertically compressed.

[0012] It has been discovered that such vertical compression substantially eliminates distortion resulting from the spatial separation between the cameras and can be readily accomplished. In an illustrated embodiment, the image compression is carried out by removing selective ones of the scan lines making up the image portion. A greater number of lines are removed further away from the vertical center of the image.

[0013] The compression of the central image portion produces a dead space in the displayed image which may be made to correspond with the area that would be occupied by the vehicle in the view from the single virtual camera. Preferably, perspective lines are included at lateral edges of the dead space which are aligned with the direction of travel of the vehicle and, therefore, appear in parallel with lane markings. This provides visual clues to the driver's sense of perspective in order to assist in judging distances of objects around the vehicle.

[0014] According to another aspect of the invention, image enhancement means are provided for enhancing the displayed image. Such means may be in the form of graphic overlays superimposed on the displayed image. Such graphic overlap may include indicia of the anticipated path of travel of the vehicle which is useful in assisting the driver in guiding the vehicle in reverse directions. Such graphic overlay may include a distance grid indicating distances behind the vehicle of objects juxtaposed with the grid.

[0015] According to yet an additional aspect of the invention, a rearview vision system for a vehicle includes at least one image capture device positioned on the vehicle and directed generally rearwardly with respect to the direction of travel of the vehicle. A display system is provided which displays a rear image synthesized from an output of the image capture device. The rear image is substantially contiguous with the forward field of view of the vehicle driver and at a focal length that is forward of the vehicle passenger compartment and preferably within the depth of field of a vehicle driver viewing a distant object. Because the image has a focal length that more closely matches that of the forward field of view observed by the driver, the need for the driver's eyes to refocus from the forward field of view to a much shorter focus distance each time the gaze of the driver is directed at the display system is minimized. This reduces the amount of time required for the driver to gaze at the displayed image and interpret objects displayed in the image. Furthermore, the reduction in the repeated refocusing of the driver's eyes reduces driver fatigue. If there are any near field objects in the periphery of the driver's forward field of view, such as windshield wipers, windshield frame, dashboard, and the like, the display system is preferably positioned in a manner which blocks the view of such near field objects. In this manner, the driver's gaze may shift between the forward field of view and the long focal length display system without being refocused on the near field objects. This is based upon a recognition that the driver's eyes will tend to refocus on the near field object momentarily even though the gaze is being redirected between the forward field of view and the display system.

[0016] According to yet an additional aspect of the invention, a rearview vision system for a vehicle includes at least one image capture device positioned on the vehicle and directed generally rearwardly with respect to the direction of travel of the vehicle. A display system is provided for displaying a rear image captured by the image capture device. The displayed image is a unitary image having an aspect ratio that is between approximately 4:1 and approximately 2:1. In a most preferred embodiment, the image has an aspect ratio that is approximately 8:3. The aspect ratio, according to this aspect of the invention, is especially useful where the unitary image is synthesized from a plurality of images which are captured by a plurality of image captured devices and are tiled by the display device.

[0017] According to yet an additional aspect of the invention, a rearview vision system for a vehicle includes a plurality of image capture devices positioned on the vehicle and directed generally rearwardly with respect to the direction of travel of the vehicle. A display system which includes at least one image generator and an optical correction system is provided which displays an image synthesized from outputs of the image capture devices as a unitary image. Alternatively, the display system may include a plurality of image generators, each associated with one or more of the image capture devices and an optical correction system which amplifies images generated by the image generators and merges them into a unitary image. The optical correction system additionally increases the focal length, or lengths, of the image, or images, generated by the image generator, or generators. The display system may be an opaque projection display which is positioned approximately at the driver's arm length in front of the driver. Alternatively, the display system may be a view-through heads-up display which projects the unitary image onto a combiner in order to combine the unitary image with the forward field of view of the driver.

[0018] These and other objects, advantages, and features of this invention will become apparent by review of the following specification in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] FIG. 1 is a top plan view of a vehicle having a rearview vision system according to the invention;

[0020] FIG. 2 is a side elevation of the vehicle in FIG. 1;

[0021] FIG. 3 is a front elevation of a display according to the invention;

[0022] FIG. 4 is the same view as FIG. 1 illustrating an alternative embodiment of the invention;

[0023] FIG. 5 is a block diagram of an electronic system according to the invention;

FIG. 6 is the same view as FIG. 3 illustrating an alternate mode of operation of the system;

[0024] FIG. 7 is the same view as FIG. 2 illustrating an alternative embodiment of the invention;

[0025] FIG. 8 is the same view as FIG. 3 illustrating an alternative embodiment of the invention;

[0026] FIG. 9 is the same view as FIGS. 1 and 4 illustrating an alternative embodiment of the invention;

[0027] FIG. 10 is the same view as FIGS. 3 and 8 illustrating an alternative embodiment of the invention;

[0028] FIG. 11 is a chart illustrating the horizontal row of pixels (n1, n2) on which an object will be imaged from two longitudinally separated image capture devices as that object is spaced at different longitudinal distances from the image capture devices;

[0029] FIG. 12 is a forward elevation of a vehicle passenger compartment as viewed by a vehicle driver;

[0030] FIG. 13 is a sectional view taken along the lines XIII-XIII in FIG. 12;

[0031] FIG. 14 is a sectional view taken along the lines XIV-XIV in FIG. 12;

[0032] FIG. 15 is the same view as FIG. 14 of an alternative embodiment;

[0033] FIG. 16 is the same view as FIG. 14 of another alternative embodiment;

[0034] FIG. 17 is an enlarged view of the display system in FIG. 14 illustrating details thereof;

[0035] FIG. 18 is a block diagram similar to FIG. 5 of an alternative embodiment of the invention;

[0036] FIG. 19 is a side elevation similar to FIG. 2 of an alternative embodiment of the invention;

[0037] FIG. 20 is an enlarged side elevation of an image capture device with portions of the housing removed in order to reveal internal structure thereof;

[0038] FIG. 21 is a block diagram similar to FIG. 5 of another alternative embodiment of the invention;

[0039] FIG. 22 is a block diagram similar to FIG. 5 of another alternative embodiment of the invention;

[0040] FIG. 23 is a block diagram similar to FIG. 5 of another alternative embodiment of the invention;

[0041] FIG. 24 is a block diagram similar to FIG. 5 of another alternative embodiment of the invention; and

[0042] FIG. 25 is a block diagram of a rearview vision system having extended dynamic range capabilities.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0043] Referring now specifically to the drawings, and the illustrative embodiments depicted therein, a vehicle 10, which may be an automobile, a light truck, a sport utility vehicle, a van, a bus, a large truck, or the like includes a rearview vision system, generally illustrated at 12, for providing a driver of the vehicle with a view rearwardly of the vehicle with respect to the direction of travel T of the vehicle (FIG. 1). Vision system 12 includes at least two side image capture devices 14 positioned, respectively, on opposite sides of vehicle 10 and a center image capture device 16 positioned on the lateral centerline of the vehicle. All of the image capture devices are directed generally rearwardly of the vehicle. Rearview vision system 12 additionally includes an image processor 18 for receiving data signals from image capture devices 14, 16 and synthesizing, from the data signals, a composite image 42 which is displayed on a display 20.

[0044] As will be set forth in more detail below, the images captured by image capture devices 14, 16 are juxtaposed on display 20 by image processor 18 in a manner which approximates the view from a single virtual image capture device positioned forwardly of the vehicle at a location C and facing rearwardly of the vehicle, with the vehicle being transparent to the view of the virtual image capture device. Vision system 12 provides a substantially seamless panoramic view rearwardly of the vehicle without duplicate or redundant images of objects. Furthermore, elongated, laterally-extending, objects, such as the earth's horizon, appear uniform and straight across the entire displayed image. The displayed image provides a sense of perspective, which enhances the ability of the driver to judge location and speed of adjacent trailing vehicles.

[0045] Each of side image capture devices 14 has a field of view 22 and is aimed rearwardly with respect to the vehicle about an axis 24 which is at an angle, with respect to the vehicle, that is half of the horizontal field of view of the image capture device. In this manner, each of the image capture devices 14 covers an area bounded by the side of the vehicle and extending outwardly at an angle defined by the horizontal field of view of the respective side image capture device. Center image capture device 16 has a horizontal field of view 26, which is symmetrical about the longitudinal axis of the vehicle. The field of view of each side image capture device 14 intersect the field of view of center image capture device 16 at a point P which is located a distance Q behind vehicle 10.

[0046] Rear blind zones 30 are located symmetrically behind vehicle 10 extending from the rear of the vehicle to point P. Side blind zones 25 located laterally on respective sides of the vehicle extend rearwardly of the forward field of view 36 of the driver to the field of view 22 of the respective side image capture device 14. An object will not be captured by side image capture devices 14 or center image capture device 16 if the object is entirely within one of the blind zones 25, 30. In order for an object, such as another vehicle V or other road user travelling to the side of vehicle 10, to be observed by an operator of vehicle 10, the object must be either at least partially within the forward field of view 36 of the driver or be captured by image capture devices 14, 16 and displayed on display 20. FIG. 4 illustrates vehicle 10 travelling on a three-lane highway having lanes L1, L2, and L3 with the vehicle in lane L2. Another vehicle V is shown positioned mostly within one of the blind zones 25, but with the rearmost portion of the vehicle V extending into field of view 22 where the vehicle image will be captured by one of side image capture devices 14. In the illustrated embodiment, vehicle V is a motorcycle travelling in the center of lanes L1 or L3 and represents a worst case for observing a vehicle travelling at least partially within one of the blind zones 25. In order for a portion of vehicle V to be extending either forwardly or rearwardly of the respective blind zone 25, where the vehicle V may be observed by either the forward field of view 36 of the driver or by the rearview vision system 12, the field of view 22 of side image capture devices 14 must be sufficiently wide to capture a portion of vehicle V as illustrated in FIG. 4. Preferably, the horizontal field of view 22 of side image capture devices 14 is no greater than that required to provide sufficient coverage which would be in the range of between approximately 55 degrees and approximately 70 degrees. In the illustrated embodiment, the horizontal field of view 22 is 61 degrees. In order for a portion of vehicle V to be within a vertical field of view 40 of one of side image capture devices 14, the field of view should extend to the pavement at a plane M which intersects vehicle V (FIG. 2). Preferably, vertical field of view 40 is between approximately 60 degrees and approximately 75 degrees. In the illustrated embodiment, vertical field of view 40 is 66 degrees.

[0047] A left overlap zone 32 and a right overlap zone 34 extend rearward from respective points P where the horizontal fields of view of the side image capture devices intersect the field of view of center image capture device 16. Overlap zones 32, 34 define areas within which an object will be captured both by center image capture device 16 and one of the

side image capture devices 14. An object in an overlap zone 32, 34 will appear on display 20 in multiple image portions in a redundant or duplicative fashion. In order to avoid the presentation of redundant information to the driver, and thereby avoid confusion and simplify the task of extracting information from the multiple images or combined images on display 20, the object should avoid overlapping zones 32, 34. In practice, this may be accomplished to a satisfactory extent by moving points P away from the vehicle and thereby increasing distance Q. It is desirable to increase distance Q to a length that will exclude vehicles travelling at a typical separation distance behind vehicle 10 from overlapping zones 32, 34. This separation distance is usually a function of the speed at which the vehicles on the highway are travelling. Therefore, optionally, distance Q may be made variable, not fixed. In such embodiment, the faster the vehicles are travelling, the further Q should be moved behind vehicle 10 to keep overlap zones 32 and 34 outside of the recommended vehicle spacing. If, however, the vehicles are travelling at a slower speed, then the generally accepted recommendation for vehicle spacing decreases and it is more likely that a vehicle will be within overlap zone 32, 34. Therefore, the distance Q may be selected to accommodate expected vehicle spacing for an average driving speed of vehicle 10.

[0048] Distance Q is a function of the effective horizontal field of view 26 of center image capture device 16. As field of view 26 decreases, points P move further rearward of the vehicle from a distance Q1, to a distance Q2, as best illustrated in FIG. 4. In order to increase distance Q to eliminate redundant and duplicative information displayed on display 20 for most driving conditions of vehicle 10, field of view 26 is preferably less than 12 degrees. In the illustrated embodiment, field of view 26 is between 6 and 8 degrees. Alternatively, distance Q may be dynamically adjusted according to some parameter, such as the speed of vehicle 10. This would allow Q to be greater when the vehicle is travelling at a faster speed, where vehicle separation tends to be larger, and vice versa. Field of view 26 may be adjusted by utilizing a selective presentation of pixels of the captured image in the displayed image.

[0049] Referring to FIG. 3, image display device 20 displays a composite image 42 made up of a left image portion 44, a right image portion 46, and a center image portion 48. Each image portion 44-48 is reversed from the image as captured by the respective image capture device 14, 16 utilizing conventional techniques. These techniques include reading

the image in reverse with the image capture device, writing the image in reverse to display device 20, or reversing the image in image processor 18. Left image portion 44 is joined with central image portion 48 at a boundary 50. Central image portion 48 is joined with right image portion 46 at a boundary 52. As may best be seen in FIG. 3, the image portions at boundaries 50 and 52 are continuous whereby composite image 42 is a seamless panoramic view rearwardly of the vehicle. As also is apparent from FIG. 3, central image portion 48 is narrower than either left image portion 44 or right image portion 46. This is a result of reducing the horizontal field of view 26 of center image capture device 16 sufficiently to move points P, and thus overlap zones 32 and 34, a sufficient distance behind vehicle 10 to reduce redundant and duplicative images between image portions 44-48. Composite image 42 provides a clear image, which avoids confusion and simplifies the task of extracting information from the multiple image portions 44-48. As also may be seen by reference to FIG. 3, display 20 may additionally include indicia such as the readout of a compass 54, vehicle speed 56, turn signals 58, and the like as well as other graphical or video displays, such as a navigation display, a map display, and a forward-facing vision system. In this manner, rearview vision system 12 may be a compass vision system or an information vision system.

[0050] In the embodiment of rearview vision system 12 having a dynamically adjusted value of distance Q, the spacing between boundaries 50 and 52 will dynamically adjust in sequence with the adjustment of distance Q. Thus, as overlap zones 32, 34 move further away from the vehicle; for example, in response to an increase in speed of the vehicle, boundary lines 50 and 52 will move closer together and vice versa. In this manner, composite image 42 is dynamic, having image portions of dynamically adaptive sizes.

[0051] Display 20 is of a size to be as natural as possible to the driver. This is a function of the size of the displayed image and the distance between the display and the driver. Preferably, the displayed image simulates an image reflected by a rearview mirror. As such, the size of the displayed image is approximately the combined areas of the three rearview mirrors (one interior mirror and two exterior mirrors) conventionally used with vehicles. As best seen by reference to FIGS. 2 and 12, display 20 is preferably positioned within the driver's physiological field of view forward of the vehicle, generally illustrated at 70, through the windshield 72 without significantly obstructing the forward field of view. It is known that the driver's field of view, with the head and eyes fixed forward, extends

further in a downward direction than in an upward direction. Display 20 could be located above the field of view 70 wherein the display may be observed at the upward portion of the driver's field of view. However, the position for the display illustrated in FIGS. 2 and 12 is preferred wherein the display is within the lower portion of the driver's field of view.

[0052] Display 20 may be a direct view flat panel display, such as a back-lit or reflective liquid crystal display, a plasma display, a field emission display, a cathode ray tube electroluminescent, light-emitting diode or deformable mirror display. The display may be mounted/attached to the dashboard, facia or header, or to the windshield at a position conventionally occupied by an interior rearview mirror. However, the synthesized image could be displayed using other display techniques such as to provide a projected or virtual image. Alternatively, a virtual image may be displayed on an opaque display adjacent the forward field of view. Alternatively, a virtual image may be displayed on a view-through heads-up display in which the image is superimposed on the forward field of view.

[0053] In the embodiment illustrated in FIGS. 12-17, display 20 displays an image at a focal length that is forward of the passenger compartment of vehicle 10. Preferably, the image displayed by display 20 is at a focal length that is within the driver's normal depth of field when viewing a distant object. Display 20 includes an image generator 74, which produces an image captured by one or more image capture devices 14, 16, and an optical correction system 76, which increases the focal distance of the image generated by image generator 74. In the illustrated embodiment, optic correction system 76 increases the focal distance by collimating the rays, generally indicated at X, from diverging rays to generally parallel rays projected from the display. Optical correction system 76 additionally magnifies the image. In the illustrated embodiment, the magnification is a factor of two. In this manner, optical corrective system 76 has the advantage of extending the focal distance of the image generated by image generator 74 and enlarging the image by the factor of magnification thereof. This advantageously allows each image generator 74 to project all or a portion of an image captured by one of image capture devices 14, 16, or a combination of portions of images from one or more image capture devices, by tiling the images or image portions. This is accomplished because the images projected from optical correction system 76 may abut even though the corresponding image generators 74 do not. This provides a convenient technique for joining the images synthesized from

the image capture devices into a unitary image which represents a panoramic view rearward of the vehicle.

[0054] In the embodiment illustrated in FIG. 14, display 20 is an opaque projection display which projects the image directly toward the driver. In the embodiment illustrated in FIG. 15, a display device 120 is a view-through heads-up display in which the rays X are projected generally upwardly by image generator 74 and optical correction system 76 which are generally vertically aligned, or aligned forward of vertical. The rays X are reflected off a first surface of windshield 72 in the direction of the driver. Windshield 72 acts as a combiner which combines the image displayed by display 120 with a portion of the forward field of view 70 observed by the driver. In the embodiment illustrated in FIG. 15, a combiner other than the windshield may be used. Examples may be holographic or diffractive optical film elements or beam splitters of metal or dielectric thin films. Furthermore, image processor 18 may generate a line in the shape of a polygon, such as a rectangle, around rear image 42. This provides a border around the image to differentiate the rear view from the view forward of the vehicle.

[0055] In the embodiment illustrated in FIG. 16, display 20A is oriented at an angle with respect to the forward field of view of driver D. Image rays X are reflected by a mirror 140 toward the driver. Display 20A is an opaque display, with mirror 140 blocking the driver's view of near field objects, such as wipers 98 and the like. Display 20A has the advantage of being capable of location within a forward portion of the dashboard. Additionally, the only portion of the display visible to the driver is mirror 140. This allows near field portions of the display to be significantly reduced.

[0056] Because display 20 has a relatively long focus distance, display 20 defines an observation cone, generally designated 78, within which the displayed image can be observed. Therefore, the head of the driver must be properly oriented with respect to observation cone 78 in order to allow the driver to observe the displayed image. However, drivers come in various sizes. Therefore, a driver may be too tall or too short to have his or her head properly positioned within observation cone 78. In order to provide for various size drivers along with various adjustments in seating positions and the like, an accommodation means, generally illustrated at 80, may be provided in order to accommodate variations in the relationship between a driver's head and observation cone 78. In the illustrated embodiment, accommodation means 80 includes adjustment means

82 for adjusting the position of observation cone 78. The adjustment means may adjust the position of the observation cone either vertically, horizontally, or both vertically and horizontally. A vertical adjustment means 82 is illustrated in FIG. 13 in which the adjustment means includes an electric actuator 84 which is joined by linkage 86 with a portion of a housing 88 of display 20. Actuator 84 is electrically interconnected through a reversing switch 90 with a driver-operated actuator 92 which may be positioned on dashboard 94 or other convenient position accessible to the driver. Housing 88 may be adjustably mounted, such as by a pivot 96, in order to allow housing 88 to be adjustably repositioned with respect to dashboard 94. In this manner, by operation of actuator 92, housing 88 may be pivoted upwardly or downwardly with respect to pivot 96 in order to adjust the direction of observation cone 78. In this manner, the location of observation cone 78 may be adjusted in order to coincide with the location of the driver's head. In a similar fashion, the position of observation cone 78 may be adjusted laterally, if desired. If a view-through heads-up display of the type illustrated in FIG. 15 is utilized, the position of the observation cone may be adjusted vertically and laterally, in a similar manner, by mechanical or optical adjustments of display 20.

[0057] Accommodation means 80 may include extending the rearward field of view displayed by display 20 laterally outwardly with respect to the bezel 89 beyond that normally observed by a driver. In this manner, a driver's head located generally centrally within observation cone 78 will observe a view generally rearwardly of the vehicle. As the driver's head is moved laterally within observation cone 78, the driver will observe images more laterally to the side of the vehicle as would occur if the driver's head were to be moved with respect to a conventional optical rearview mirror system.

[0058] Vehicle 10 may include one or more near field view objects adjacent forward field of view 70. One such object is a windshield wiper 98 of the vehicle. Other such objects may include the top of dashboard 94, the frame around windshield 72, the hoodline, and the like. The housing of display 20 in FIG. 14 and mirror 140 in FIG. 15 are positioned with respect to forward field of view 70 such that housing 88 or mirror 140 covers any near field of view objects in the portion of the forward field of view adjacent display 20, 20A. In this manner, the gaze of the driver can switch between forward field of view 70 and the image displayed on display 20, without the eyes of the driver focusing on any significant near field objects. This is based upon a discovery that, even though the eyes of the driver are

switching between the long focal distance of the forward field of view and the long focal distance of the image displayed by display 20, the eyes of the operator will unconsciously momentarily focus on any near field object positioned between the long focal distance views. Therefore, by blocking the driver's gaze of any near field objects, the eyes of the driver will be less stimulated to refocus during the transition from field of view 70 to display 20 and back again.

[0059] Image processor 18, which supplies a video signal 100 to image generator 74, may have a second input 102 which modulates the intensity level of the image generated by image generator 74 and displayed by display 20 (FIG. 14). The illumination level of the display is set in response to an ambient light input 104 which is an indication of the ambient light level around vehicle 10. Image processor 18 responds to the value of ambient light input 104 by producing a luminance intensity signal 102 which increases the intensity of the display in response to increases in ambient light level and decreases the intensity of the display in response to decreases in ambient light level. However, the level of display luminance may be limited to vary between upper and lower limits such that, once ambient light reaches a particular upper level, further increases in ambient light level will not result in a further increase in display intensity. Likewise, once the ambient light level decreases below a particular value, further reductions in ambient light level will not result in further reduction in display intensity. Ambient light input 104 may be produced by a separate ambient light sensor of the type which produces a continuously variable output in response to variations in ambient light levels, in which case, the intensity of display 20 may be proportionately adjusted. Alternatively, ambient light input 104 may be produced by a vehicle headlight control system (not shown) which switches the vehicle headlights on, or to a nighttime condition, in response to decreases in ambient light levels and switches the vehicle headlights off, or to a daytime running light condition, in response to increasing ambient light levels. Such system is disclosed in commonly assigned U.S. patent application Ser. No. 08/277,674 filed on Jul. 19, 1994, by Kenneth L. Schierbeek and Niall R. Lynam for an AUTOMATIC REARVIEW MIRROR SYSTEM WITH AUTOMATIC HEADLIGHT ACTIVATION, the disclosure of which is hereby incorporated herein by reference. If the ambient light signal supplied to ambient light input 104 is a binary signal representative of a daytime ambient light level and a nighttime ambient light level, image processor 18 would typically provide a signal on luminance intensity line 102

that would switch the intensity level of display 20 between two intensity levels. Alternatively, ambient light input 104 may be supplied with a signal developed by one or more image capture devices 14, 16. The ambient light signal would be based upon an average intensity value sensed by all, or a group of, pixels in the image capture device or devices. This embodiment eliminates the necessity for a separate ambient light sensor. Alternatively, ambient light input 104 may be responsive to manual actuation of the vehicle's headlights by the driver. Additionally, a comfort level setting may be provided to allow the driver to adjust to a preferred brightness at one ambient light condition. Thereafter, the system automatically adjusts display brightness according to ambient light changes.

[0060] In the illustrated embodiment, display 20 incorporates a combined image generator and optical correction system 106 which provides for both image magnification and light ray collimation. In this manner, the image projected from display 20 is larger than the image generated by image generator 74 and has a focal length that is greater than the separation distance between the image generator and the driver and, preferably, is generally at infinity (FIG. 17). Combined image generator and an optical correction system 106 is disclosed in detail in U.S. Pats. 5,050,966 for an OPTICAL COMBINER COLLIMATING APPARATUS; 4,859,031 for an OPTICAL COLLIMATING APPARATUS; 4,900,133 for a HEADS-UP DISPLAY COMBINER UTILIZING A CHOLESTERIC LIQUID CRYSTAL ELEMENT; 4,987,410 for a MULTIPLE IMAGE FORMING APPARATUS; and 5,408,346 for an OPTICAL COLLIMATING DEVICE EMPLOYING CHOLESTERIC LIQUID CRYSTAL AND NON-TRANSMISSIVE REFLECTOR, the disclosures of which are hereby incorporated herein by reference and will not be repeated. Suffice it to say, combined image generator and optical correction system 106 includes a light source 108 which generates broad band white light which is gathered and reflected by a parabolic reflector 110. In the illustrative embodiment, light source 108 is a tungsten halogen incandescent lamp. The light rays then pass through a dielectric green filter 112 which passes light in a specific region of the green portion of the spectrum and through a hot mirror 114 which removes the infrared content of the spectrum. Light then passes through a holographic diffuser 116 which homogenizes and shapes the light pattern. The light rays then pass through a monochrome liquid crystal display with opposing linear polarizers 118 which is supplied with a video signal by image processor 18. Items 108-118 make up

image generator 74, which, in the illustrative embodiment, is a transmissive backlit liquid crystal display. However, image generator 74 could additionally be an emissive display or a reflective display, all of which are well known in the art.

[0061] Light rays of the image generated by image generator 74 next pass through an anti-reflective coated cover glass 120 which is joined with a left-hand circular polarizer 122 which is bonded to this cover glass. The opposite surface of circular polarizer 122 is bonded to a lens 124 having a 50/50 dielectric coating. Such dielectric coating allows light rays to be both transmitted through the lens and reflected by the lens. The left-hand polarized light X' transmitted through lens 124 contacts a cholesteric liquid crystal layer (CLC) 126 which is left-hand polarized, which is what gives efficient reflection of left-hand polarized light X', as illustrated at X''. Fifty percent (50%) of light rays X'' get efficiently reflected by the 50/50 beam splitter on lens 124 as right-hand circular polarized light X'''. Right-hand polarized light X''' is transmitted by CLC layer 126 and passes through a right-hand circular polarizer 128 and an anti-reflective coated cover glass 130.

[0062] As can be seen by reference to FIG. 17, the optical configuration of lens 124 in combination with the left-hand and right-hand circular polarizers 122, 128 and cholesteric liquid crystal layer (CLC) 126, provide image magnification as well as collimate the image light in order to produce a very long focal distance image. Advantageously, this structure allows image portions from multiple image capture devices to be tiled into a unitary image. FIG. 17 illustrates an approach using a single image generator. Merging of multiple image portions would require additional combined image generator and optical correction systems. Although image generators 74 for each of the image portions are laterally spaced apart from each other, the amplification produced by combined image generator and optical correction system 106 causes the image portions to merge at their periphery. FIG. 17 illustrates an approach using a single image generator. Merging of multiple image portions would require additional combined image generators and optical correction systems. Other optical elements such as prisms, or other lenses, may be necessary to merge images to form a unitary image. Although the invention is illustrated with a combined image generator and optical correction system using cholesteric liquid crystal optical processing, other optical correction systems, as are known in the art, may be used. What is required is that the optical system generally collimates the light generated by the image generator and, preferably, provides amplification to the generated image.

[0063] In the illustrated embodiment, rear image 42, synthesized from the output of image capture devices 14, 16, has a lateral width verses vertical height aspect ratio that is between approximately 4:1 and 2:1. Most preferably, the aspect ratio of image 42 is 8:3. This allows a panoramic view rearwardly of the vehicle with an optimum information content while reducing display of irrelevant information. The aspect ratio of display 20 may be different from that of the displayed synthesized image 42. The remaining portion of the display, either above or below image 42, may be utilized to display images other than synthesized image 42. For example, the remaining portion of the display can be used to display auxiliary information such as one or more vehicle-operating parameters, such as vehicle speed indicia 56, heading indicia 54, or turn signal indicia 58. Alternatively, the remaining portion of the display can be a reconfigurable high-information content display area to selectively display various types of information. Such information may include incoming facsimile or pager information, phone numbers, and navigational aids including pull-up maps, route guidance information, global positioning system (GPS) data, intelligent vehicle highway system (IVHS) information, as well as radio and environmental system control settings, and the like. Display 20 is especially useful for displaying such alternative data. Because display 20 has a very long focal length, the driver may consult the alternative data by switching the gaze of the driver between forward field of view 70 and to display 20 which does not require extensive refocusing of the driver's eyes. This allows the driver to consult the alternative data quickly with reduced fatigue and distraction. The content of the auxiliary information displayed may be user-selectable by a keypad, trackball, or other input device on the dashboard, steering column, or other position readily accessible to the driver.

[0064] Although various camera devices may be utilized for image capture devices 14, 16, an electro-optic, pixilated imaging array, located in the focal plane of an optical system, is preferred. Such imaging array allows the number of pixels to be selected to meet the requirements of rearview vision system 12. The pixel requirements are related to the imaging aspect ratio of the respective image capture devices, which, in turn, are a function of the ratio of the vertical-to-horizontal field of view of the devices, as is well known in the art. In the illustrated embodiment, the imaging aspect ratio of side image capture devices 14 is 2:1 and the image aspect ratio of central image capture device 16 is variable down to 0.1:1. Such aspect ratio will produce images which will not typically match that of

commercially available displays. A commercially available display may be used, however, by leaving a horizontal band of the display for displaying alpha-numeric data, such as portions of an instrument cluster, compass display, or the like, as illustrated in FIG. 3.

[0065] In the illustrated embodiment, image capture devices 14, 16 are CMOS imaging arrays of the type manufactured by VLSI Vision Ltd. of Edinburgh, Scotland, which are described in more detail in co-pending U.S. patent application Ser. No. 08/023,918 filed Feb. 26, 1993, now U.S. Pat. No. 5,550,677, the disclosure of which is hereby incorporated herein by reference. However, other pixilated focal plane image-array devices, which are sensitive to visible or invisible electromagnetic radiation, could be used. The devices could be sensitive to either color or monochromatic visible radiation or near or far infrared radiation of the type used in night-vision systems. Each image capture device could be a combination of different types of devices, such as one sensitive to visible radiation combined with one sensitive to infrared radiation. Examples of other devices known in the art include charge couple devices and the like.

[0066] Preferably, image capture devices 14 and 16 are all mounted at the same vertical height on vehicle 10, although compromise may be required in order to accommodate styling features of the vehicle. The horizontal aim of image capture devices 14 and 16 is preferably horizontal. However, the portion of the image displayed is preferably biased toward the downward portion of the captured image because significantly less useful information is obtained above the horizontal position of the image capture devices.

[0067] Each image-capturing device 14, 16 is controlled by appropriate supporting electronics (not shown) located in the vicinity of the imaging array such that, when operating power is supplied, either an analog or a digital data stream is generated on an output signal line supplied to image processor 18. The support electronics may be provided partially on the image chip and partially on associated electronic devices. For each exposure period, a value indicative of the quantity of light incident on each pixel of the imaging array during the exposure period is sequentially outputted in a predetermined sequence, typically row-by-row. The sequence may conform to video signal standards which support a direct view such that, when a scene is viewed by an image-capturing device, the image presented on a display represents directly the scene viewed by the image-capturing devices. However, when looking forward and observing a displayed image of a rearward scene, the driver will interpret the image as if it were a reflection of

the scene as viewed through a mirror. Objects to the left and rearward of the vehicle, as viewed by the rearward-looking camera, are presented on the left-hand side of the display and vice versa. If this reversal is effected in image processor 18, it may be by the use of a data storage device, or buffer, capable of storing all of the pixel values from one exposure period. The data is read out of the data storage device in a reversed row sequence. Alternatively, the imaging array electronics could be constructed to provide the above-described reversal at the image-capturing device or at the display.

[0068] Data transmission between image capture devices 14, 16 and image processor 18 and/or between image processor 18 and display 20 may be by electrically conductive leads. The leads may comprise either a serial or parallel bus. Alternatively, the data transmission may be via plastic or glass fiber-optic cable or an RF link. It is possible, for particular applications, to eliminate image processor 18 and direct drive display 20 from image capture devices 14, 16 at the pixel level. This may be accomplished by providing an interface between the output of image capture device 14, 16 and display 20 which synchronously maps image pixels captured by the image capture device, or devices, to the display. This synchronous mapping may be accomplished by providing a one-to-one mapping in which each pixel measurement is communicated to the display. Alternatively, the interface may only transmit pixel data which represents changes in the captured image. This allows for a reduction in the communication bandwidth necessary to transmit data between the image capture device, or devices, and the display. This may be accomplished by encoding the pixel data which represents changes in the captured image with additional data which designates the position of the pixel or other relevant information. Communication between the image capture device, or devices, may be multiplexed.

[0069] The data streams from image-capturing devices 14, 16 are combined in image processor 18 and directly mapped to the pixel array of display 20. This process is repeated preferably at a rate of at least 30 times per second in order to present an essentially real time video image. The image captured by side image capture device 14 on the right side of the vehicle is presented in right image portion 46 and the image from side image capture device 14 on the left side of the vehicle is displayed on left image portion 44. The image from center image capture device 16 is displayed on central image portion 48. The three image portions 44-48 are presented in horizontal alignment and

adjacent to each other. However, the composite image may be positioned at any desired vertical position in the display 20. It is also possible to display image portions 44-48 on separate image devices which are adjacent each other.

[0070] In vision system 12, side image capture devices 14 are positioned preferably at a forward longitudinal position on vehicle 10 and center image capture device 16 is positioned at a rearward longitudinal position on the vehicle. As best seen by reference to FIG. 7, this positioning creates a difference in the vertical angle between each side image capture device 14 and center image capture device 16 with respect to a fixed location P1 that is a distance D1 behind the vehicle. This difference in sensing angle will cause each side image capture device 14 to image an object located at P1 on a horizontal row of pixels that is different from the horizontal row of pixels that center image capture device 16 will image the same object. If the image is below the horizontal centerline of the image capture device, it will be imaged on a lower row of pixels by center image capture device 16 than the row of pixels it will be imaged by the side image capture devices 14, as illustrated in FIG. 7. This mismatch between horizontal pixel rows of the captured image is furthermore a function of the distance of the captured image from the rear of the vehicle. This can be understood by reference to FIG. 11 which presents a chart 90 having a first column 92 of pixel lines n1, measured from the array centerline, at which an object will be imaged by side image capture device 14 and a second column 94 of pixel lines n2, measured from the array vertical centerline, at which the same object will be imaged by center image capture device 16. The result is that an object, which is captured by both side and center image capture devices 14, 16, will be vertically disjointed at the boundary of the displayed image, if the object is captured by more than one image capture device. The amount of disjointment will be greater closer to the vehicle and less at further distances. If the object is elongated in the horizontal direction, such as earth's horizon, bridges, or cross-markings on highways, then the object will appear to be either broken or crooked.

[0071] In order to provide uniform display of laterally elongated images, a rearview vision system 12' is provided having a central image portion 48' which is processed differently from the image display portions 44' and 46' produced by the side image capture devices (FIG. 8). Central image portion 48' is reduced vertically, or compressed, by removing specified scan lines, or pixel rows, from the image captured by center image capture

device 16 in a graduated fashion. The difference in the pixel line at which an object will be imaged by each of the side and center image capture devices is a function of the distance D of the object from the rear of the vehicle, with a greater variation occurring at shorter distances and the variation reducing to zero for infinite distances. Therefore, the compression of central image portion 48' is non-linear, with substantially no compression at the vertical center of the image and greater compression at greater distances above and below the vertical center point of the image. This is accomplished by removing specific lines from the center display in a graduated fashion with a greater number of lines removed further from the vertical center of the image. The removed lines may be merely discarded in order to vertically reduce the image. Alternatively, the data contained in the removed lines may be utilized to modify the value of adjacent pixels above and below the removed line in order to enhance the quality of the compressed image. Averaging, median filtering, or other such known techniques may also be used.

[0072] Each of right image portion 46' and left image portion 44' includes an upper portion 64 which extends above the compressed upper portion of the central image portion 48'. In the illustrated embodiment, upper portions 64 are deleted in order to present a uniform upper horizontal boundary for display 20'. In the illustrated embodiment, the mismatch between the lower horizontal boundary of central image portion 48' and each of the left and right image portions provides a dead space 66 which provides a visual prompt to the user of the approximate location of the rearward corners S of vehicle 10. This dead space 66 in the image displayed on display 20' approximates the footprint occupied by vehicle 10 when viewed from point C. This is particularly useful because it provides a visual indication to the driver that a vehicle passing vehicle 10, as viewed in either left image portion 44' or right image portion 46', is at least partially adjacent vehicle 10 if the image of the approaching vehicle is partially adjacent to dead space 66.

[0073] In an alternative embodiment, the vertical compression technique may be applied to only a lower vertical portion of central image portion 48'. In most driving situations, objects imaged by rearward-facing image capture devices above the horizon are at a long distance from the vehicle while those below the horizon get progressively closer to the vehicle in relation to the distance below the horizon in the displayed image. Therefore, compression of the upper vertical portion of the central image portion may be eliminated without significant reduction in performance.

[0074] Compression of the central image portion may also advantageously be provided horizontally, as well as vertically. Spatial separation of center image capture device 16 from side image capture devices 14 causes similar distortion, as that described above, in the horizontal direction. This effect is spherical in nature and would require a more complex corrective action, such as compressing the image based upon the removal of pixels from an approximation to concentric circles centered on the center of the imaging array, or other techniques which would be apparent to those skilled in the art.

[0075] A rearview vision system 12'' includes an image display 20'' having a compressed central image portion 48'' and left and right image portions 44'' and 46'', respectively (FIG. 10). A border 50' between left side image 44'' and central image 48'' includes a vertical central border portion 50a', an upper border portion 50b', and a lower border portion 50c'. Upper border portion 50b' and lower border portion 50c' diverge laterally outwardly, vertically away from central portion 50a'. A border 52' between central image portion 48'' and right image portion 46'' includes a central boundary portion 52a', an upper boundary portion 52b', and a lower boundary portion 52c'. Upper boundary portion 52b' and lower boundary portion 52c' diverge laterally outwardly vertically away from central portion 52a'. This creates an upper portion of central image portion 48'' and a lower portion of central image portion 48'' which extend beyond the center portion thereof. This configuration is based upon the realization that the surface of the road immediately behind the vehicle is captured by central image capture device 16. Likewise, the horizontal plane above the vehicle, which is symmetrical with the road surface, is captured by the center image capture device. This may be seen by referring to point P in FIG. 10, which illustrate the points where the effective radius 68 of the virtual image capture device intersects dead zones 30 and by referring to point S in FIG. 10 which illustrates the corners or the rear of the vehicle (S).

[0076] The image displayed on display 20'' includes a dead space 66' having diverging lateral sides 68a, 68b. Diverging sides 68a and 68b are configured in order to extend in the direction of travel of vehicle 10 which is parallel to lane markings of a highway on which vehicle 10 is travelling. This further enhances the visual perception of the driver by providing a visual clue of the location of images appearing on display 20'' with respect to the vehicle 10. Side portions 68a, 68b, in the illustrated embodiment, are natural extensions of lower boundary portions 50c' and 52c' and extend from point S on each

respective side of the vehicle to point R, which represents the intersection of the lower extent of the vertical field of view 40 of each side image capture device 14 with the pavement (FIG. 7).

[0077] Rearview vision systems 12' and 12" utilize a displayed synthesized image which takes into account the use of perspective in enhancing the driver's understanding of what is occurring in the area surrounding the vehicle. The images produced on displays 20' and 20" effectively remove the vehicle bodywork and replace the bodywork with a vehicle footprint as would be viewed by virtual camera C. The image displayed on display 20" further includes perspective lines which further enhance the roll of perspective in the driver's understanding of what is occurring.

[0078] In order to further enhance the driver's understanding of what is occurring in the area surrounding the vehicle, a rearview vision system 12'" includes a display 20'" having image enhancements (FIG. 6). In the illustrative embodiment, such image enhancements include graphic overlays 70a, 70b which are hash marks intended to illustrate to the driver the anticipated path of movement of vehicle 10. In the illustrated embodiment, the anticipated vehicle motion is a function of the vehicle direction of travel as well as the rate of turn of the vehicle. The forward or rearward direction of vehicle travel is determined in response to the operator placing the gear selection device (not shown) in the reverse gear position. The degree of turn of the vehicle may be determined by monitoring the movement of the vehicle steering system, monitoring the output of an electronic compass, or monitoring the vehicle differential drive system. In the embodiment illustrated in FIG. 6, the configuration of graphic overlays 70a, 70b indicates that the vehicle is in reverse gear and that the wheels are turned in a manner that will cause the vehicle to travel toward the driver's side of the vehicle. If the wheels were turned in the opposite direction, graphic overlays 70a, 70b would curve clockwise toward the right as viewed in FIG. 6. If the vehicle's wheels were straight, graphic overlays 70a, 70b would be substantially straight converging lines. If the vehicle is not in reverse gear position, graphic overlays 70a, 70b are not presented. Other types of graphic overlays of the displayed image are comprehended by the invention.

[0079] Horizontal grid markings on the display may be provided to indicate distances behind the vehicle at particular markings. Such grid would allow the driver to judge the relative position of vehicles behind the equipped vehicle. In one embodiment, short

horizontal lines are superimposed on the displayed image at regular rearward intervals in horizontal positions which correspond to the boundaries of the lane in which the vehicle is travelling. In order to avoid confusion when the vehicle is travelling in a curved path, from a lack of correspondence between the graphic overlay and the road, a signal indicative of the vehicle's rate of turn may be taken into account when generating the graphic overlay. In this manner, the distance indications may be moved laterally, with reduced horizontal separation, to correspond to the positions of the curved lane boundaries and vertically on the image to compensate for the difference between distances along a straight and curved path.

[0080] Another image enhancement is to alter the appearance of an object in a particular zone surrounding the vehicle in order to provide an indication, such as a warning, to the driver. As an example, a vehicle that is too close to the equipped vehicle for safe-lane change, may be displayed in a particular color, such as red, may flash, or otherwise be distinguishable from other images on the display. Preferably, the speed of the equipped vehicle 10, which may be obtained from known speed transducers, may be provided as an input to the rearview vision system in order to cause such warning to be a function of the vehicle speed which, in turn, affects the safe separation distance of vehicles. The operation of the turn signal may also be used to activate such highlighting of other road users or to modify the scope of the image displayed. In order to determine the distance of objects behind vehicle 10, a separate distance-measuring system may be used. Such separate system may include radar, ultrasonic sensing, infrared detection, and other known distance-measuring systems. Alternatively, stereoscopic distance-sensing capabilities of side image capture devices 14 may be utilized to determine the separation distance from trailing objects utilizing known techniques.

[0081] Thus, it is seen that the image displayed on display 20-20"' may be different under different circumstances. Such different circumstances may relate to the vehicle's direction of travel, speed, rate of turn, separation from adjacent objects, and the like.

[0082] Various other forms of image processing may be utilized with rearview vision system 12-12"'. Luminant and chrominant blending may be applied to the images captured by image capture devices 14, 16 in order to produce equality of the image data whereby the image portions appear as if they were produced by one image capture device. The dynamic range of the image capture devices may be extended in order to

provide high quality images under all lighting conditions. Furthermore, individual pixel groups may be controlled in order to selectively compensate for bright or dark spots. For example, anti-blooming techniques may be applied for bright spots. Multiple exposure techniques may be applied to highlight dark areas. Image morphing and warping compensation techniques may additionally be applied. Resolution of the image capture devices and display may be selected in order to provide sufficient image quality for the particular application.

[0083] A heater may be applied to each image capture device in order to remove dew and frost that may collect on the optics of the device. Although, in the illustrative embodiment, the optical centerline of the camera coincides with the field of view, particular applications may result in the centerline of the camera pointing in a direction other than the centerline of the field of view. Although, in the illustrative embodiment, the image capture devices are fixed, it may be desirable to provide selective adjustability to the image capture devices or optical paths in particular applications. This is particularly desirable when the system is used on articulated vehicles where automated and coordinated camera aim may be utilized to maintain completeness of the synthesized image.

[0084] When operating the vehicle in the reverse direction, it may be desirable to provide additional data concerning the area surrounding the immediate rear of the vehicle. This may be accomplished by utilizing non-symmetrical optics for the center image capture device in order to provide a wide angle view at a lower portion of the field of view. Alternatively, a wide angle optical system could be utilized with the electronic system selectively correcting distortion of the captured image. Such system would provide a distortion-free image while obtaining more data, particularly in the area surrounding the back of the vehicle.

[0085] The invention additionally comprehends the use of more than three image capture devices. In addition to side image capture devices positioned at the front sides of the vehicle and a center image capture device positioned at the center rear of the vehicle, additional image capture devices may be useful at the rear corners of the vehicle in order to further eliminate blind spots. It may additionally be desirable to provide an additional center image capture device at a higher elevation in order to obtain data immediately behind the vehicle and thereby fill in the road surface detail immediately behind the vehicle. Such additional detail is particularly useful when operating the vehicle in the

reverse direction. Of course, each of the image capture devices could be a combination of two or more image capture devices.

[0086] Although the present invention is illustrated as used in a rearview vision system, it may find utility in other applications. For example, the invention may be useful for providing security surveillance in an area where a building or other object obstructs the view of the area under surveillance. Additionally, the invention may find application in night-vision systems and the like. For example, the invention may be applied to forward-facing night-vision systems, or other vision enhancement systems such as may be used in adverse weather or atmospheric conditions such as fog, applied to provide an enhanced display of a synthesized image, which approximates a forward-facing view from a single virtual camera located rearwardly of the driver, taking advantage of the perspective features of the image.

[0087] A rearview vision system 150 is provided which, in addition to displaying a rear image on display 20 which is synthesized by image processor 18 from the output of image capture devices 14, 16, also supplies drive signals to an electrically operated optical device such as electro-optic mirror 152, an electro-optic window 154, or both. Even though a panoramic view rearward of the vehicle is displayed on display 20, it may be desired to provide the driver with a rearview mirror of the type which has conventionally been provided on vehicles. One such mirror is an electro-optic mirror, such as an electrochromic mirror, a liquid crystal mirror, or a solenoid-operated prismatic mirror and the like. Additionally, vehicles may be provided with electro-optic windows, such as sunroofs, rear windows, side windows, and the like, which change transmissivity in response to a drive signal to a partial light transmittance level. In U.S. patent application Ser. No. 08/023,918 filed Feb. 26, 1993, now U.S. Pat. No. 5,550,677, the disclosure of which is hereby incorporated herein by reference, a technique is disclosed for producing a drive signal for an electrically operated optical device, such as an electro-optic mirror or window, from the image captured by a rearward-facing array. Utilizing the techniques disclosed therein, image processor 18 produces a drive signal on line 156 in order to control the partial reflectance level of electro-optic mirror 152 and a drive signal on line 158 in order to control the partial light transmittance level of electro-optic window 154.

[0088] A rearview vision system 160 is provided which includes a near infrared illumination device 162 in order to enhance an image captured by image capture devices 14, 16 (FIG.

19). In the illustrated embodiment, infrared illumination device 162 illuminates an area immediately behind the vehicle. Preferably, the output of illumination device 162 has a greater near infrared light output than visible light output. This allows an enhanced image to be captured by the image capture device without increasing the visible light perceived by drivers surrounding the vehicle. Infrared illumination device 162 may be actuated in response to the vehicle being placed in reverse gear. This provides backup illumination which is greatly enhanced without having an increased effect on other drivers. Alternatively, infrared illumination devices may be positioned, for example, at other locations on the side or even the front of a vehicle in order to enhance the image captured by the image capture device or devices. This is especially useful in order to utilize rearview vision system 160 with a large truck, such as a trailer truck. This infrared illumination device may flood the area around the trailer with infrared light in order to enhance the image captured by the image capture device, or devices, without distracting other drivers.

[0089] Image capture device 14, 16 may include a housing 164 in which an antenna 166 is positioned. This provides a convenient and functional location for a receiving antenna, such as the type used with a global positioning system, cellular telephone, garage door opener, radar distance sensing device, and the like, as disclosed in patent application Ser. No. 08/569,851 filed by O'Farrell et al., now U.S. Pat. No. 5,971,552, the disclosure of which is hereby incorporated herein by reference. A heater 168 may be associated with the image capture device in order to stabilize the temperature of the device in low ambient temperature conditions. A similar heater may be supplied in display 20 in order to improve its performance in low ambient temperature conditions. A heater control 170 is provided in order to control the energization of heater 168 and, if utilized, the heater in the display. Heater control 170, preferably, energizes heater 168 prior to the vehicle being started. This allows the temperature of the image capture device to be elevated to a more desirable temperature prior to the driver operating the vehicle. This may be accomplished by heater control 170 being a proximity detector which detects a device carried by the driver as the driver approaches the vehicle. Alternatively, heater control 170 may be responsive to a signal produced by a remote keyless entry device concurrently with the doors being activated. Alternatively, heater control 170 may be responsive to the vehicle device being opened.

[0090] A rearview vision system 172 is provided which provides an output, generally referred to at 174, from image processor 18 to display 20. Output 174 provides an indication when an object bears a predetermined relationship to the vehicle. Such object may be of interest because the object is in a blind spot of the vehicle, may be tailgating the vehicle, or may be an object in front of the vehicle which the vehicle is too close to. Display 20 may respond to output 174 by highlighting the displayed vehicle, such as by displaying the vehicle in an artificial color, such as red, by flashing the image of the vehicle, or, otherwise, drawing the attention of the driver to the vehicle. Output 174 may be developed by image processor 18 from the outputs of image capture devices 14, 16. This may be accomplished by, for example, utilizing redundant image portions captured by the image capture devices, even though not displayed by display 20, in order to calculate relative position of the object with respect to the vehicle. Alternatively, an object sensor 176 may be provided in order to supply an output 178 indicative of a predetermined positional relationship of an object sensed by the object sensor with respect to the vehicle. In the illustrated embodiment, object sensor 176 may be a passive infrared sensor which senses the presence of an object in the vehicle's blind spot. Alternatively, object sensor 176 may be a distance-measuring device, such as an active infrared sensor, an ultrasonic sensor, a radar sensor, or the like. Such object sensor is especially useful in determining the separation distance between the vehicle and objects in front of the vehicle. Preferably, object sensor 176 has a sensing field of view that is substantially coincident with the field of view of one or more of the image capture devices 14, 16.

[0091] A rearview vision system 178 is provided which has the capability of displaying stereoscopic images rearward of the vehicle. Rearview vision system 178 includes at least one pair of image capture devices 14a, which are closely positioned on the vehicle and have overlapping fields of view. Because the image capture device pairs are closely positioned, they capture substantially the same image but from a slightly different angle. This allows image processor 18 to produce a video signal 100' with stereoscopic information. This signal is utilized by a stereoscopic display 320 in order to produce a stereoscopic image rearward of the vehicle. Such stereoscopic displays are known in the art. Although one pair of image capture devices are illustrated in FIG. 22, rearview vision system 178 may include multiple pairs of image capture devices. This allows a rear image to be synthesized from the multiple pairs of image capture devices in order produce a

panoramic view rearward of the vehicle and stereoscopic image. Preferably, utilizing other aspects of the invention, the stereoscopic image is a rearward-facing view from a single location.

[0092] A rearview vision system 180 is provided which produces an indication 182 of road line markings. Indication 182 may also indicate road edges. Image processor 18 detects the road line markings and the road edges from the images captured by image capture devices 14, 16. This feature may be further enhanced by combining it with an infrared illumination device 162 in order to further illuminate areas behind and around the vehicle in order to enhance the image of the road line markings and the road edges. Indication 182 may be utilized by display 20 in order to provide an indication of the vehicle with respect to the road line markings and road edges. The indication may further be utilized by an indicator which indicates the relative position of the vehicle in its lane. Additionally, the indication may be utilized to determine erotic vehicle operation, such as may occur when the driver begins to fall asleep, in order to provide a suitable alarm, or the like.

[0093] A rearview vision system 184 is provided with capabilities for infrared communication with other vehicles and stationary beacons. Rearview vision system 184 produces a communication data output 186 which includes communication data decoded from infrared signals detected by image capture device or devices 14, 16. For example, suitable standards may be developed wherein vehicles are equipped with a pair of spaced apart infrared transmitters on a forward portion thereof. Image processor 18 may respond to the temporal and spatial patterns of infrared signals detected by image capture devices 14, 16 in order to determine the speed and distance and, thereby, the separation of the vehicles as well as the rate of change of separation of the vehicles. Such information may be communicated to the trailing vehicle by an infrared transmitter (not shown) in order to control the speed of the trailing vehicle. This feature provides adaptive cruise control in which the speed of the trailing vehicle is controlled according to separation distance with leading vehicles. This allows high-speed convoying between vehicles. The communication system may additionally provide for the identification of emergency vehicles, and the like, which may transmit a unique temporal and/or spatial pattern of an infrared signal. The IR communication signal may additionally be utilized to receive signals from stationary devices, such as location beacons and Intelligent Vehicle Highway System (IVHS) data. Because rearview vision system 184 has a field of view which

extends generally rearwardly of the vehicle, the system provides the capability for sensing information after the vehicle has passed the beacon. This provides an adjunct to infrared communication systems having a field of view generally forward of, or to the side of, the vehicle.

[0094] A rearview vision system 188 is provided having extended dynamic range (FIG. 25). Rearview vision system 188 includes a pair of image capture devices 14 and/or 16, each of which has an image-sensing array 190. Each image capture device is capable of operating in either a color mode, in which a color image is displayed on display 20, or a monochrome mode, in which a monochrome image is displayed on display 20. System 188 includes an image luminance sensor 192 which senses the luminance level of images captured by image capture devices 14, 16. Image luminance sensor 192 may switch the image capture devices between the color mode and the monochrome mode such that, when the image luminance is sufficiently high, the image capture device, or devices, operate in a color mode. During low image luminance conditions, the image capture device, or devices, are operated in a monochromatic mode which does not require as much image luminance. This extends the dynamic range of the system. Rearview vision system 188 may additionally include an exposure control 194 which determines the exposure period for capturing each frame by arrays 190. In order to extend the dynamic range of system 188, exposure control 194 may produce exposure intervals for arrays 190 which vary in length from interval-to-interval. Thus, a series of normal exposure intervals may be occasionally supplanted by a longer exposure interval during which greater detail of the image may be captured. This enhanced image may then be combined with the image captured during the shorter intervals into a merged image of enhanced detail.

[0095] Rearview vision system 188 may additionally include a plurality of infrared shutters 196 which are in the optical paths 198 of arrays 190. Each infrared shutter 196 has at least one state in which infrared energy is generally not attenuated to array 190. In another state, the infrared shutter generally blocks infrared radiation from the array. The state of infrared shutters 196 is controlled by image luminance sensor 192. During periods of high image luminance, sensor 192 may switch the infrared shutters 196 to a state blocking near infrared radiation from arrays 190. However, during low image luminance conditions, sensor 198 may switch the infrared shutters 196 to a state in which the near infrared energy is transmitted to arrays 190. The addition of the near infrared

radiation at low luminance levels enhances the image luminance sensed by arrays 190. In the illustrated embodiment, infrared shutters 196 are either electrochromic shutters or liquid crystal shutters, both of which are known in the art. Rearview vision system 188 additionally includes means for coordinating the image intensity received from multiple image capture devices and displayed on display 20. This allows a balance composite image to be displayed on the display. This may be provided by a display intensity control 200 which regulates the intensity of the output of both arrays 190 in order to produce color and luminance balancing between the multiple image capture devices. Instead of a separate display intensity control, a direct communication channel may be developed between the image capture devices in order to provide color and luminance balancing.

[0096] Each image pixel captured by image capture devices 14, 16 and displayed on display 20 has a resolution which affects the amount of image detail displayed. While it is desirable to have a high degree of detail of displayed image, the increase in image resolution produces a commensurate increase in system cost. While it is desirable to reduce system cost, this should not be achieved by sacrificing necessary detail in the displayed image. According to the invention, it has been determined that sufficient image detail may be obtained at a suitable system cost by having a pixel resolution in the range of between approximately 2 arc minutes and approximately 8 arc minutes. Preferably, system resolution is approximately 6 arc minutes.

[0097] It is known in the art to provide imaging array capture devices having mosaic filters which mask image radiation in order to produce pixels which respond respectively to red, green, and blue light. Because such known pixel filter masks do not adequately absorb near infrared radiation, it is known to supply infrared filters in order to block infrared radiation from the pixels so that the pixels respond to only the designed radiation band. However, such additional filters have undesirable characteristics including costs. It has been discovered that a pixel filter mask may be made responsive to red, green, or blue light while filtering out near infrared by adding appropriate dyes to the dyes making up the filter mask.

[0098] The heater supplied with each image capture device may include a transparent conductive coating applied to a window covering the device lens. Alternative heater constructions include ITO or a series of fine wire mesh. This provides protection of the

lens of the image capture device from physical harm while allowing moisture and frost to be removed from the window.

[0099] Various manipulation techniques may be applied to image capture devices 14, 16. For example, when the invention is applied to semi-tractor/trailer combinations, the image capture devices may be motorized and responsive to signals representing the relative position of the trailer and the cab in order to produce full panoramic view during various maneuvers of the vehicle. For example, as the vehicle turns, which may cause the trailer to otherwise block the image captured by a side image capture device, the image capture device may pivot to a different panoramic view which is not blocked by the trailer. Additionally, the panoramic view sensed by the image capture device may be different when the trailer is attached than when the trailer is not attached. In a similar fashion, rearward-mounted image capture device 16 may be motorized to move vertically upwardly and downwardly between a first position when the vehicle is moving in a forward direction and a second position when the vehicle is in reverse gear. In the second position, the motorized camera is directed more downwardly in order to capture images closer to the rear of the vehicle which may be contacted by the vehicle. Image capture devices 14, 16 may be supplied with electrical opto-mechanical zoom devices as well as vibration isolation and compensation stabilizing devices.

[00100] Image processor 18 may provide an input to a control for the intensity of the brake lights, turn signals, and the like for the vehicle. In this manner, the image processor may control the intensity of such lights based upon ambient lighting conditions. This allows the intensity of the rearward directed lights to be less distracting for following vehicles.

[00101] Additionally, the present invention may be utilized for providing guidance for a tractor/trailer or like vehicle backing to a loading dock. Additionally, the invention may provide guidance for proper alignment of the trailer and tractor which are being joined by backing of the tractor. The present invention may additionally provide accident monitoring by capturing a predetermined continuous stream of images, such as, for example, 15 seconds. This running store of image may be frozen upon impact of the vehicle, in order to record events leading up to the impact, or may be stopped by a manual input. Furthermore, the invention may be utilized to alert the driver to an impending rear-end collision. The vehicle may respond to such indication by deploying an appropriate device, such as a smart headrest or the like.

[00102] Thus, it is seen that the present invention enhances the relationship between the driver's primary view and the image presented on the rearview vision system. This is accomplished in a manner which provides ease of interpretation while avoiding confusion so that the driver does not have to concentrate or look closely at the image. In this manner, information presented on the display is naturally assimilated. This is accomplished while reducing blind spots so that other vehicles or objects of interest to the driver will likely be displayed to the driver. Additionally, the use of perspective allows distances to be more accurately determined.

[00103] Changes and modifications in the specifically described embodiments can be carried out without departing from the principles of the invention, which is intended to be limited only by the scope of the appended claims, as interpreted according to the principles of patent law including the doctrine of equivalents.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A multi-camera vision system for a vehicle, said vehicular multi-camera vision system comprising:

at least three image capture devices disposed at a vehicle equipped with said vehicular multi-camera vision system;

said at least three image capture devices comprising a first image capture device disposed at a driver-side portion of the equipped vehicle at a first location;

said at least three image capture devices comprising a second image capture device disposed at a passenger-side portion of the equipped vehicle at a second location;

said at least three image capture devices comprising a third image capture device disposed a rear portion of the equipped vehicle at a third location;

wherein said first image capture device has a first field of view exterior of the equipped vehicle;

wherein said second image capture device has a second field of view exterior of the equipped vehicle;

wherein said third image capture device has a third field of view exterior of the equipped vehicle;

wherein said first field of view of said first image capture device overlaps with said third field of view of said third image capture device defining a first overlap zone;

wherein said second field of view of said second image capture device overlaps with said third field of view of said third image capture device defining a second overlap zone;

wherein said first image capture device captures first image data;

wherein said second image capture device captures second image data;

wherein said third image capture device captures third image data;

an image processor;

wherein first image data captured by said first image capture device is received at said image processor via at least one of an analog data stream and a digital data stream;

wherein second image data captured by said second image capture device is received at said image processor via at least one of an analog data stream and a digital data stream;

wherein third image data captured by said third image capture device is received at said image processor via at least one of an analog data stream and a digital data stream;

wherein, responsive to processing by said image processor of received image data, a synthesized image is generated without duplication of objects present in said first overlap zone and in said second overlap zone and wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle; and

wherein said synthesized image is displayed by a single display screen of a reconfigurable display device that is viewable by a driver of the equipped vehicle when normally operating the equipped vehicle.

2. The vehicular multi-camera vision system of claim 1, wherein said single location is forward of the equipped vehicle.

3. The vehicular multi-camera vision system of claim 1, wherein first image data captured by said first image capture device is received at said image processor via a digital data stream and wherein second image data captured by said second image capture device is received at said image processor via a digital data stream and wherein third image data captured by said third image capture device is received at said image processor via a digital data stream.

4. The vehicular multi-camera vision system of claim 1, wherein image data transmission from said first, second and third image capture devices to said image processor is by electrically conductive leads over a vehicle communication bus.

5. The vehicular multi-camera vision system of claim 4, wherein said vehicle communication bus comprises a serial bus.

6. The vehicular multi-camera vision system of claim 4, wherein said vehicle communication bus comprises a parallel bus.

7. The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen includes a visual indication of the location of the equipped vehicle in said view.

8. The rearview multi-camera vision system of claim 7, wherein said visual indication approximates the footprint occupied by the equipped vehicle.

9. The vehicular multi-camera vision system of claim 7, wherein said visual indication comprises an outline of an area substantially occupied by the equipped vehicle.

10. The vehicular multi-camera vision system of claim 1, wherein said first image capture device is disposed at the equipped vehicle at substantially the same height relative to ground as is said second image capture device.

11. The vehicular multi-camera vision system of claim 10, wherein said first location where said first image capture device is disposed at the driver-side of the equipped vehicle is a first distance forward of where the driver sits when operating the equipped vehicle and wherein said second location where said second image capture device is disposed at the passenger-side of the equipped vehicle is a second distance forward of where the driver sits when operating the equipped vehicle.

12. The vehicular multi-camera vision system of claim 11, wherein said first distance is substantially the same as said second distance.

13. The vehicular multi-camera vision system of claim 11, wherein said third image capture device is at a height relative to ground that is lower than the height relative to ground of said first and second image capture devices, and wherein said third location is a third distance rearward of where the driver sits when operating the equipped vehicle and wherein said third distance is larger than either of said first and second distances.

14. The vehicular multi-camera vision system of claim 1, wherein said at least three image capture devices have the principal axis of their respective field of view aimed along non-parallel axes.

15. The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen approximates a rearward-facing view from a single location exterior of the equipped vehicle.

16. The vehicular multi-camera vision system of claim 15, wherein said single location is forward of the equipped vehicle.

17. The vehicular multi-camera vision system of claim 1, wherein a fourth image capture device is disposed at a front portion of the equipped vehicle.

18. The vehicular multi-camera vision system of claim 17, wherein said single location is rearward of the equipped vehicle.

19. The vehicular multi-camera vision system of claim 1, wherein each of said at least three image capture devices comprises a CMOS imaging array.

20. The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen comprises a graphic overlay.

21. The vehicular multi-camera vision system of claim 20, wherein said graphic overlay comprises indicia of the anticipated path of travel of the equipped vehicle.

22. The vehicular multi-camera vision system of claim 20, wherein said graphic overlay comprises indicia indicating distance to objects exterior the equipped vehicle.

23. The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen comprises enhancements that assist visually distinguishing objects close to the equipped vehicle.

24. The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen comprises indicia and wherein said indicia responds to at least one of the vehicle's steering system, the vehicle's differential system and a compass.

25. The vehicular multi-camera vision system of claim 1, wherein at least one of color and flashing is used to draw the driver's attention to a potential hazard present in the image displayed by said display screen.

26. The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen comprises a graphic overlay that includes indicia of the anticipated path of travel of the equipped vehicle and wherein said graphic overlay is disabled when the vehicle's gear actuator is not in reverse gear.

27. The vehicular multi-camera vision system of claim 1, wherein the display luminance of said display screen of said reconfigurable display device is variable responsive to a sensing of an ambient light level.

28. The vehicular multi-camera vision system of claim 1, wherein the display luminance of said display screen of said reconfigurable display device is variable responsive to at least one of (i) a vehicle headlight activation control, (ii) an ambient light sensor and (iii) an indication of ambient light level detected by at least one of said first, second and third image capture devices.

29. The vehicular multi-camera vision system of claim 1, wherein said display screen of said reconfigurable display device is operable to display at least one of (i) pager information, (ii) a telephone number listing, (iii) global positioning system data, (iv) a map, (v) route guidance information, (vi) intelligent vehicle highway system information, (vii) a

vehicle radio control setting, (viii) a vehicle environmental system setting, (ix) vehicle speed, (x) vehicle heading, (xi) turn signal indicators and (xii) a radio setting.

30. The vehicular multi-camera vision system of claim 1, wherein content displayed by said display screen of said reconfigurable display device is user-selectable.

31. The vehicular multi-camera vision system of claim 1, wherein content displayed by said display screen of said reconfigurable display device is user-selectable via at least one of a keypad and a trackball.

32. The vehicular multi-camera vision system of claim 1, wherein content displayed by said display screen of said reconfigurable display device is user-selectable via an input device located at a steering column of the equipped vehicle or at a dashboard of the equipped vehicle.

33. The vehicular multi-camera vision system of claim 1, wherein said reconfigurable display device comprises a flat-panel display device.

34. The vehicular multi-camera vision system of claim 33, wherein said flat-panel display device comprises a back-lit liquid crystal display device.

35. The vehicular multi-camera vision system of claim 33, wherein said flat-panel display device comprises a light-emitting diode display device.

36. The vehicular multi-camera vision system of claim 33, wherein said flat-panel display device comprises a plasma display device.

37. The vehicular multi-camera vision system of claim 33, wherein said flat-panel display device is mounted at a dashboard of the equipped vehicle.

38. The vehicular multi-camera vision system of claim 33, wherein said flat-panel display device is mounted at a facia of the equipped vehicle.

39. The vehicular multi-camera vision system of claim 33, wherein each of said at least three image capture devices comprises an array of photosensing pixels and wherein a mosaic spectral filter masks incident radiation in order to produce pixels which respond respectively to red, green and blue light.

40. The vehicular multi-camera vision system of claim 33, wherein each of said at least three image capture devices comprises an array of photosensing pixels and comprises filtering to least one of (a) at least partially block near infrared radiation from pixels of said array and (b) at least partially block infrared radiation from pixels of said array.

41. The vehicular multi-camera vision system of claim 1, wherein at least one (a) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle into a loading dock, (b) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle with a trailer attached thereto, (c) said vehicular multi-camera vision system provides accident monitoring, (d) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and (e) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and to deploy a smart headrest in such an event.

42. The vehicular multi-camera vision system of claim 1, wherein said first field of view said first image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom.

43. The vehicular multi-camera vision system of claim 1, wherein said second field of view said second image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom.

44. The vehicular multi-camera vision system of claim 1, wherein said display device comprises a circular polarizer.

45. The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen comprises a focal length that is substantially the depth of the field of the driver viewing objects beyond said equipped vehicle.

46. The vehicular multi-camera vision system of claim 1, wherein said synthesized image displayed by said display screen approximates a panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle.

47. The vehicular multi-camera vision system of claim 1, wherein said synthesized image displayed by said display screen approximates a substantially seamless panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle.

48. The vehicular multi-camera vision system of claim 1, wherein said synthesized image displayed by said display screen approximates a substantially seamless view as would be viewed from a single virtual camera located exterior the equipped vehicle.

49. A multi-camera vision system for a vehicle, said vehicular multi-camera vision system comprising:

at least three image capture devices disposed at a vehicle equipped with said vehicular multi-camera vision system;

said at least three image capture devices comprising a first image capture device disposed at a driver-side portion of the equipped vehicle at a first location;

said at least three image capture devices comprising a second image capture device disposed at a passenger-side portion of the equipped vehicle at a second location;

said at least three image capture devices comprising a third image capture device disposed at a rear portion of the equipped vehicle at a third location;

wherein said first image capture device has a first field of view exterior of the equipped vehicle;

wherein said second image capture device has a second field of view exterior of the equipped vehicle;

wherein said third image capture device has a third field of view exterior of the equipped vehicle;

wherein said first field of view of said first image capture device overlaps with said third field of view of said third image capture device defining a first overlap zone;

wherein said second field of view of said second image capture device overlaps with said third field of view of said third image capture device defining a second overlap zone;

wherein said first image capture device captures first image data;

wherein said second image capture device captures second image data;

wherein said third image capture device captures second image data;

wherein each of said at least three image capture devices comprises a CMOS imaging array;

wherein said first image capture device is disposed at the equipped vehicle at substantially the same height relative to ground as is said second image capture device;

wherein said third vehicular camera disposed at the rear of the equipped vehicle is operable as a backup camera;

an image processor;

wherein first image data captured by said first image capture device is received at said image processor;

wherein second image data captured by said second image capture device is received at said image processor;

wherein third image data captured by said third image capture device is received at said image processor;

wherein, responsive to processing by said image processor of received image data, a synthesized image is generated without duplication of objects present in said first overlap zone and in said second overlap zone and wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle;

wherein said synthesized image is displayed by a single display screen of a reconfigurable display device that is viewable by a driver of the equipped vehicle when normally operating the equipped vehicle; and

wherein at least one of (a) said synthesized image displayed by said display screen approximates a panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle, (b) said synthesized image displayed by said display screen approximates a substantially seamless panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle and (c) said synthesized image displayed by said display screen approximates a substantially seamless view as would be viewed from a single virtual camera located exterior the equipped vehicle.

50. The vehicular multi-camera vision system of claim 49, wherein first image data captured by said first image capture device is received at said image processor via a digital data stream and wherein second image data captured by said second image capture device is received at said image processor via a digital data stream and wherein third image data captured by said third image capture device is received at said image processor via a digital data stream.

51. The vehicular multi-camera vision system of claim 49, wherein image data transmission from said first, second and third image capture devices to said image processor is by electrically conductive leads over a vehicle communication bus.

52. The vehicular multi-camera vision system of claim 49, wherein the image displayed by said display screen includes a visual indication of the location of the equipped vehicle in said view and wherein at least one of (a) said visual indication approximates the footprint occupied by the equipped vehicle and (b) wherein said visual indication comprises an outline of an area substantially occupied by the equipped vehicle.

53. The vehicular multi-camera vision system of claim 49, wherein said first location where said first image capture device is disposed at the driver-side of the equipped vehicle is a first distance forward of where the driver sits when operating the equipped vehicle and wherein said second location where said second image capture device is disposed at the passenger-side of the equipped vehicle is a second distance forward of where the driver sits when operating the equipped vehicle, and wherein said first distance is substantially the same as said second distance, and wherein said third image capture device is at a

height relative to ground that is lower than the height relative to ground of said first and second image capture devices, and wherein said third location is a third distance rearward of where the driver sits when operating the equipped vehicle and wherein said third distance is larger than either of said first and second distances.

54. The vehicular multi-camera vision system of claim 49, wherein said at least three image capture devices have the principal axis of their respective field of view aimed along non-parallel axes.

55. The vehicular multi-camera vision system of claim 49, wherein the image displayed by said display screen comprises a graphic overlay and wherein at least one of (i) said graphic overlay comprises indicia of the anticipated path of travel of the equipped vehicle and (ii) said graphic overlay comprises indicia indicating distance to objects exterior the equipped vehicle.

56. The vehicular multi-camera vision system of claim 49, wherein at least one of (a) the image displayed by said display screen comprises enhancements that assist visually distinguishing objects close to the equipped vehicle, (b) the image displayed by said display screen comprises indicia and wherein said indicia responds to at least one of the vehicle's steering system, the vehicle's differential system and a compass, (c) at least one of color and flashing is used to draw the driver's attention to a potential hazard present in the image displayed by said display screen and (d) the image displayed by said display screen comprises a graphic overlay that includes indicia of the anticipated path of travel of the equipped vehicle and wherein said graphic overlay is disabled when the vehicle's gear actuator is not in reverse gear.

57. The vehicular multi-camera vision system of claim 49, wherein at least one of (a) the display luminance of said display screen of said reconfigurable display device is variable responsive to a sensing of an ambient light level and (b) the display luminance of said display screen of said reconfigurable display device is variable responsive to at least one of (i) a vehicle headlight activation control, (ii) an ambient light sensor and (iii) an

indication of ambient light level detected by at least one of said first, second and third image capture devices.

58. The vehicular multi-camera vision system of claim 49, wherein at least one of (a) said display screen of said reconfigurable display device is operable to display at least one of (i) pager information, (ii) a telephone number listing, (iii) global positioning system data, (iv) a map, (v) route guidance information, (vi) intelligent vehicle highway system information, (vii) a vehicle radio control setting, (viii) a vehicle environmental system setting, (ix) vehicle speed, (x) vehicle heading, (xi) turn signal indicators and (xii) a radio setting, (b) content displayed by said display screen of said reconfigurable display device is user-selectable, (c) content displayed by said display screen of said reconfigurable display device is user-selectable via at least one of a keypad and a trackball, and (d) content displayed by said display screen of said reconfigurable display device is user-selectable via an input device located at a steering column of the equipped vehicle or at a dashboard of the equipped vehicle.

59. The vehicular multi-camera vision system of claim 49, wherein at least one of (a) said reconfigurable display device comprises a flat-panel display device, (b) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a back-lit liquid crystal display device, (c) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a plasma display device, (d) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a light-emitting diode display device, (e) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device is mounted at a dashboard of the equipped vehicle and (f) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device is mounted at a facia of the equipped vehicle.

60. The vehicular multi-camera vision system of claim 49, wherein at least one of (a) each of said at least three image capture devices comprises an array of photosensing pixels and wherein a mosaic spectral filter masks incident radiation in order to produce

pixels which respond respectively to red, green and blue light and (b) each of said at least three image capture devices comprises an array of photosensing pixels and comprises filtering to least one of (i) at least partially block near infrared radiation from pixels of said array and (ii) at least partially block infrared radiation from pixels of said array.

61. The vehicular multi-camera vision system of claim 49, wherein at least one (a) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle into a loading dock, (b) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle with a trailer attached thereto, (c) said vehicular multi-camera vision system provides accident monitoring, (d) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and (e) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and to deploy a smart headrest in such an event.

62. The vehicular multi-camera vision system of claim 49, wherein said first field of view said first image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom and wherein said second field of view said second image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom.

63. The vehicular multi-camera vision system of claim 49, wherein said display device comprises a circular polarizer.

64. The vehicular multi-camera vision system of claim 49, wherein at least one of (a) said synthesized image displayed by said display screen approximates a panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle, (b) said synthesized image displayed by said display screen approximates a substantially seamless panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle and (c) said synthesized image displayed by said display screen approximates a substantially seamless view as would be viewed from a single virtual camera located exterior the equipped vehicle.

65. A multi-camera vision system for a vehicle, said vehicular multi-camera vision system comprising:

at least three image capture devices disposed at a vehicle equipped with said vehicular multi-camera vision system;

said at least three image capture devices comprising a first image capture device disposed at a driver-side portion of the equipped vehicle at a first location;

said at least three image capture devices comprising a second image capture device disposed at a passenger-side portion of the equipped vehicle at a second location;

said at least three image capture devices comprising a third image capture device disposed at a rear portion of the equipped vehicle at a third location;

wherein said first image capture device has a first field of view exterior of the equipped vehicle;

wherein said second image capture device has a second field of view exterior of the equipped vehicle;

wherein said third image capture device has a third field of view exterior of the equipped vehicle;

wherein said first field of view of said first image capture device overlaps with said third field of view of said third image capture device defining a first overlap zone;

wherein said second field of view of said second image capture device overlaps with said third field of view of said third image capture device defining a second overlap zone;

wherein said first image capture device captures first image data;

wherein said second image capture device captures second image data;

wherein said third image capture device captures second image data;

wherein each of said at least three image capture devices comprises a CMOS imaging array;

wherein said third vehicular camera disposed at the rear of the equipped vehicle is operable as a backup camera;

an image processor;

wherein first image data captured by said first image capture device is received at said image processor;

wherein second image data captured by said second image capture device is received at said image processor;

wherein third image data captured by said third image capture device is received at said image processor;

wherein, responsive to processing by said image processor of received image data, a synthesized image is generated without duplication of objects present in said first overlap zone and in said second overlap zone and wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle; and

wherein said synthesized image is displayed by a single display screen of a reconfigurable display device that is viewable by a driver of the equipped vehicle when normally operating the equipped vehicle.

66. The vehicular multi-camera vision system of claim 65, wherein at least one of (a) first image data captured by said first image capture device is received at said image processor via a digital data stream and wherein second image data captured by said second image capture device is received at said image processor via a digital data stream and wherein third image data captured by said third image capture device is received at said image processor via a digital data stream and (b) image data transmission from said first, second and third image capture devices to said image processor is by electrically conductive leads over a vehicle communication bus.

67. The vehicular multi-camera vision system of claim 65, wherein the image displayed by said display screen includes a visual indication of the location of the equipped vehicle in said view and wherein at least one of (a) said visual indication approximates the footprint occupied by the equipped vehicle and (b) wherein said visual indication comprises an outline of an area substantially occupied by the equipped vehicle.

68. The vehicular multi-camera vision system of claim 65, wherein said first image capture device is disposed at the equipped vehicle at substantially the same height relative to ground as is said second image capture device, and wherein said first location where said first image capture device is disposed at the driver-side of the equipped vehicle

is a first distance forward of where the driver sits when operating the equipped vehicle and wherein said second location where said second image capture device is disposed at the passenger-side of the equipped vehicle is a second distance forward of where the driver sits when operating the equipped vehicle, and wherein said first distance is substantially the same as said second distance, and wherein said third image capture device is at a height relative to ground that is lower than the height relative to ground of said first and second image capture devices, and wherein said third location is a third distance rearward of where the driver sits when operating the equipped vehicle and wherein said third distance is larger than either of said first and second distances.

69. The vehicular multi-camera vision system of claim 65, wherein at least one of (a) said at least three image capture devices have the principal axis of their respective field of view aimed along non-parallel axes and (b) said display device comprises a circular polarizer.

70. The vehicular multi-camera vision system of claim 65, wherein the image displayed by said display screen comprises a graphic overlay and wherein at least one of (i) said graphic overlay comprises indicia of the anticipated path of travel of the equipped vehicle and (ii) said graphic overlay comprises indicia indicating distance to objects exterior the equipped vehicle.

71. The vehicular multi-camera vision system of claim 65, wherein at least one of (a) the image displayed by said display screen comprises enhancements that assist visually distinguishing objects close to the equipped vehicle, (b) the image displayed by said display screen comprises indicia and wherein said indicia responds to at least one of the vehicle's steering system, the vehicle's differential system and a compass, (c) at least one of color and flashing is used to draw the driver's attention to a potential hazard present in the image displayed by said display screen and (d) the image displayed by said display screen comprises a graphic overlay that includes indicia of the anticipated path of travel of the equipped vehicle and wherein said graphic overlay is disabled when the vehicle's gear actuator is not in reverse gear.

72. The vehicular multi-camera vision system of claim 65, wherein at least one of (a) the display luminance of said display screen of said reconfigurable display device is variable responsive to a sensing of an ambient light level and (b) the display luminance of said display screen of said reconfigurable display device is variable responsive to at least one of (i) a vehicle headlight activation control, (ii) an ambient light sensor and (iii) an indication of ambient light level detected by at least one of said first, second and third image capture devices.

73. The vehicular multi-camera vision system of claim 65, wherein at least one of (a) said display screen of said reconfigurable display device is operable to display at least one of (i) pager information, (ii) a telephone number listing, (iii) global positioning system data, (iv) a map, (v) route guidance information, (vi) intelligent vehicle highway system information, (vii) a vehicle radio control setting, (viii) a vehicle environmental system setting, (ix) vehicle speed, (x) vehicle heading, (xi) turn signal indicators and (xii) a radio setting, (b) content displayed by said display screen of said reconfigurable display device is user-selectable, (c) content displayed by said display screen of said reconfigurable display device is user-selectable via at least one of a keypad and a trackball, (d) content displayed by said display screen of said reconfigurable display device is user-selectable via an input device located at a steering column of the equipped vehicle or at a dashboard of the equipped vehicle, (e) said reconfigurable display device comprises a flat-panel display device, (f) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a back-lit liquid crystal display device, (g) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a plasma display device, (h) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a light-emitting diode display device, (i) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device is mounted at a dashboard of the equipped vehicle and (j) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device is mounted at a facia of the equipped vehicle.

74. The vehicular multi-camera vision system of claim 65, wherein at least one of (a) each of said at least three image capture devices comprises an array of photosensing pixels and wherein a mosaic spectral filter masks incident radiation in order to produce pixels which respond respectively to red, green and blue light and (b) each of said at least three image capture devices comprises an array of photosensing pixels and comprises filtering to least one of (i) at least partially block near infrared radiation from pixels of said array and (ii) at least partially block infrared radiation from pixels of said array.

75. The vehicular multi-camera vision system of claim 65, wherein at least one of (a) said synthesized image displayed by said display screen approximates a panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle, (b) said synthesized image displayed by said display screen approximates a substantially seamless panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle and (c) said synthesized image displayed by said display screen approximates a substantially seamless view as would be viewed from a single virtual camera located exterior the equipped vehicle.

76. The vehicular multi-camera vision system of claim 65, wherein at least one (a) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle into a loading dock, (b) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle with a trailer attached thereto, (c) said vehicular multi-camera vision system provides accident monitoring, (d) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and (e) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and to deploy a smart headrest in such an event.

77. The vehicular multi-camera vision system of claim 65, wherein said first field of view said first image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom and wherein said second field of view said second image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom.

78. A multi-camera vision system for a vehicle, said vehicular multi-camera vision system comprising:

at least three image capture devices disposed at a vehicle equipped with said vehicular multi-camera vision system;

said at least three image capture devices comprising a first image capture device disposed at a driver-side portion of the equipped vehicle at a first location;

said at least three image capture devices comprising a second image capture device disposed at a passenger-side portion of the equipped vehicle at a second location;

said at least three image capture devices comprising a third image capture device disposed at a rear portion of the equipped vehicle at a third location;

wherein said first image capture device has a first field of view exterior of the equipped vehicle;

wherein said second image capture device has a second field of view exterior of the equipped vehicle;

wherein said third image capture device has a third field of view exterior of the equipped vehicle;

wherein said first field of view of said first image capture device overlaps with said third field of view of said third image capture device defining a first overlap zone;

wherein said second field of view of said second image capture device overlaps with said third field of view of said third image capture device defining a second overlap zone;

wherein said first field of view said first image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom and wherein said second field of view said second image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom;

wherein said first image capture device captures first image data;

wherein said second image capture device captures second image data;

wherein said third image capture device captures second image data;

wherein each of said at least three image capture devices comprises a CMOS imaging array;

wherein said third vehicular camera disposed at the rear of the equipped vehicle is operable as a backup camera;

an image processor;

wherein first image data captured by said first image capture device is received at said image processor;

wherein second image data captured by said second image capture device is received at said image processor;

wherein third image data captured by said third image capture device is received at said image processor;

wherein, responsive to processing by said image processor of received image data, a synthesized image is generated without duplication of objects present in said first overlap zone and in said second overlap zone and wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle;

wherein said synthesized image is displayed by a single display screen of a reconfigurable display device that is viewable by a driver of the equipped vehicle when normally operating the equipped vehicle;

wherein at least one of (a) first image data captured by said first image capture device is received at said image processor via a digital data stream and wherein second image data captured by said second image capture device is received at said image processor via a digital data stream and wherein third image data captured by said third image capture device is received at said image processor via a digital data stream and (b) image data transmission from said first, second and third image capture devices to said image processor is by electrically conductive leads over a vehicle communication bus; and

wherein at least one of (a) said synthesized image displayed by said display screen approximates a panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle, (b) said synthesized image displayed by said display screen approximates a substantially seamless panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle and (c) said synthesized image displayed by said display screen approximates a substantially seamless view as would be viewed from a single virtual camera located exterior the equipped vehicle.

79. The vehicular multi-camera vision system of claim 78, wherein the image displayed by said display screen includes a visual indication of the location of the equipped vehicle in said view and wherein at least one of (a) said visual indication approximates the footprint occupied by the equipped vehicle and (b) wherein said visual indication comprises an outline of an area substantially occupied by the equipped vehicle.

80. The vehicular multi-camera vision system of claim 78, wherein said first image capture device is disposed at the equipped vehicle at substantially the same height relative to ground as is said second image capture device, and wherein said first location where said first image capture device is disposed at the driver-side of the equipped vehicle is a first distance forward of where the driver sits when operating the equipped vehicle and wherein said second location where said second image capture device is disposed at the passenger-side of the equipped vehicle is a second distance forward of where the driver sits when operating the equipped vehicle, and wherein said first distance is substantially the same as said second distance, and wherein said third image capture device is at a height relative to ground that is lower than the height relative to ground of said first and second image capture devices, and wherein said third location is a third distance rearward of where the driver sits when operating the equipped vehicle and wherein said third distance is larger than either of said first and second distances.

81. The vehicular multi-camera vision system of claim 78, wherein the image displayed by said display screen comprises a graphic overlay and wherein at least one of (i) said graphic overlay comprises indicia of the anticipated path of travel of the equipped vehicle and (ii) said graphic overlay comprises indicia indicating distance to objects exterior the equipped vehicle.

82. The vehicular multi-camera vision system of claim 78, wherein at least one of (a) the image displayed by said display screen comprises enhancements that assist visually distinguishing objects close to the equipped vehicle, (b) the image displayed by said display screen comprises indicia and wherein said indicia responds to at least one of the vehicle's steering system, the vehicle's differential system and a compass, (c) at least one of color and flashing is used to draw the driver's attention to a potential hazard present in

the image displayed by said display screen and (d) the image displayed by said display screen comprises a graphic overlay that includes indicia of the anticipated path of travel of the equipped vehicle and wherein said graphic overlay is disabled when the vehicle's gear actuator is not in reverse gear.

83. The vehicular multi-camera vision system of claim 78, wherein at least one of (a) the display luminance of said display screen of said reconfigurable display device is variable responsive to a sensing of an ambient light level and (b) the display luminance of said display screen of said reconfigurable display device is variable responsive to at least one of (i) a vehicle headlight activation control, (ii) an ambient light sensor and (iii) an indication of ambient light level detected by at least one of said first, second and third image capture devices.

84. The vehicular multi-camera vision system of claim 78, wherein at least one of (a) said display screen of said reconfigurable display device is operable to display at least one of (i) pager information, (ii) a telephone number listing, (iii) global positioning system data, (iv) a map, (v) route guidance information, (vi) intelligent vehicle highway system information, (vii) a vehicle radio control setting, (viii) a vehicle environmental system setting, (ix) vehicle speed, (x) vehicle heading, (xi) turn signal indicators and (xii) a radio setting, (b) content displayed by said display screen of said reconfigurable display device is user-selectable, (c) content displayed by said display screen of said reconfigurable display device is user-selectable via at least one of a keypad and a trackball, (d) content displayed by said display screen of said reconfigurable display device is user-selectable via an input device located at a steering column of the equipped vehicle or at a dashboard of the equipped vehicle, (e) said reconfigurable display device comprises a flat-panel display device, (f) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a back-lit liquid crystal display device, (g) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a plasma display device, (h) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a light-emitting diode display device, (i) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display

device is mounted at a dashboard of the equipped vehicle and (j) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device is mounted at a facia of the equipped vehicle.

85. The vehicular multi-camera vision system of claim 78, wherein at least one of (a) each of said at least three image capture devices comprises an array of photosensing pixels and wherein a mosaic spectral filter masks incident radiation in order to produce pixels which respond respectively to red, green and blue light and (b) each of said at least three image capture devices comprises an array of photosensing pixels and comprises filtering to least one of (i) at least partially block near infrared radiation from pixels of said array and (ii) at least partially block infrared radiation from pixels of said array.

86. The vehicular multi-camera vision system of claim 78, wherein at least one (a) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle into a loading dock, (b) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle with a trailer attached thereto, (c) said vehicular multi-camera vision system provides accident monitoring, (d) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and (e) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and to deploy a smart headrest in such an event.

MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

ABSTRACT OF THE DISCLOSURE

A multi-camera vision system for a vehicle includes first, second and third image capture devices disposed at respective vehicle portions. The first image capture device field of view overlaps with the third image capture device field of view defining a first overlap zone, and the second image capture device field of view overlaps with the third image capture device field of view defining a second overlap zone. Responsive to processing by an image processor of received image data, a synthesized image is generated without duplication of objects present in the first overlap zone and in the second overlap zone. The synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the vehicle, and is displayed by a single display screen of a reconfigurable display device that is viewable by a driver of the vehicle when normally operating the vehicle.

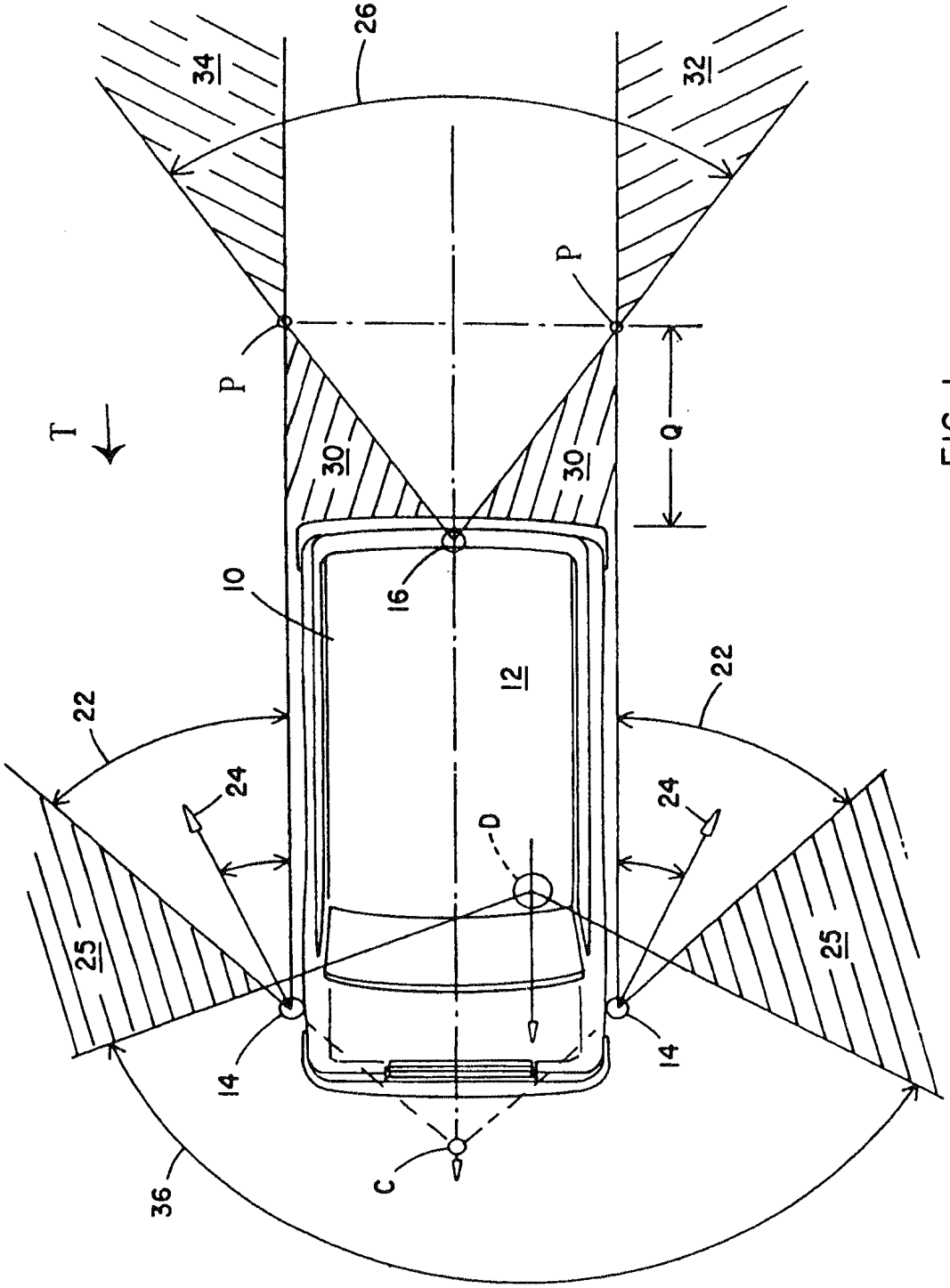


FIG. 1

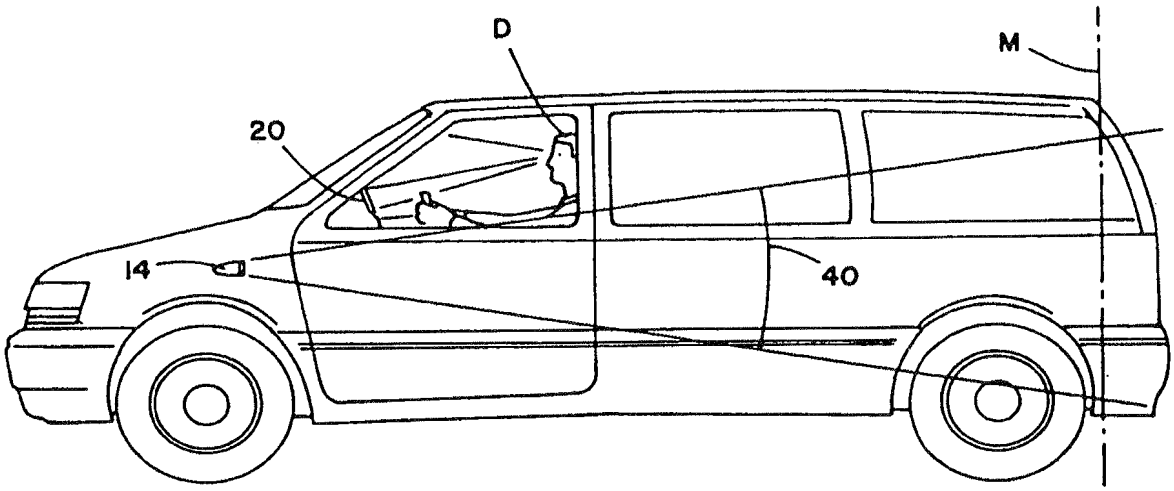


FIG. 2

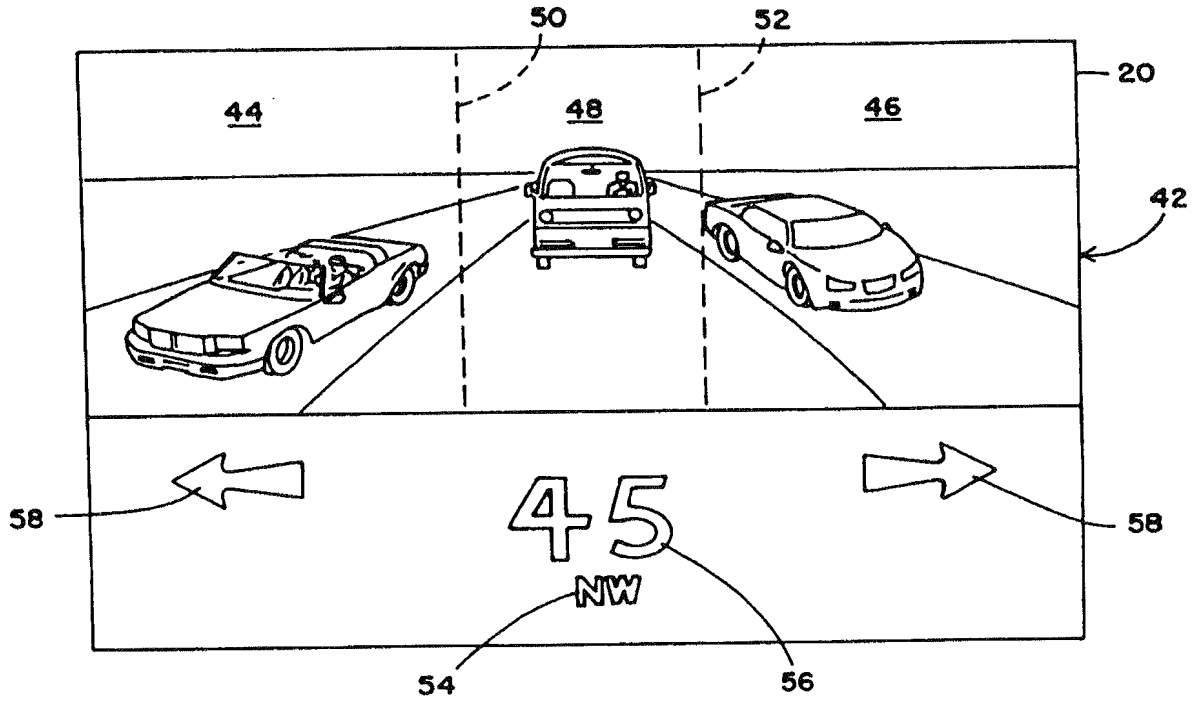


FIG. 3

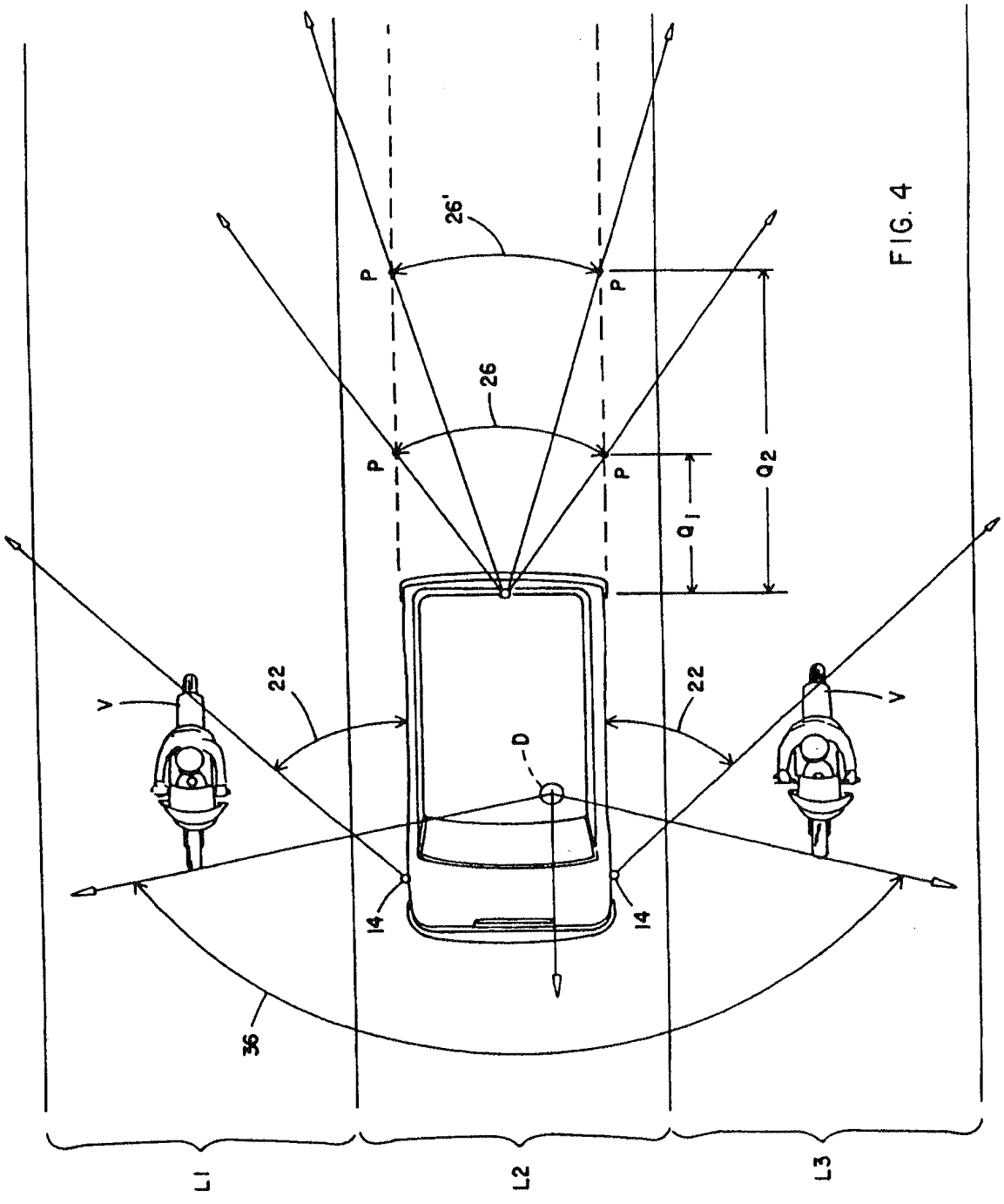


FIG. 4

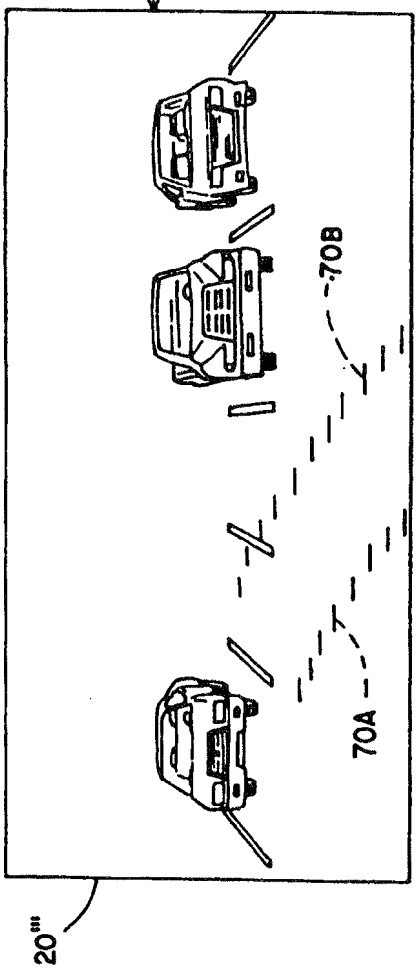

12'''
70B
70A
20'''

FIG. 6

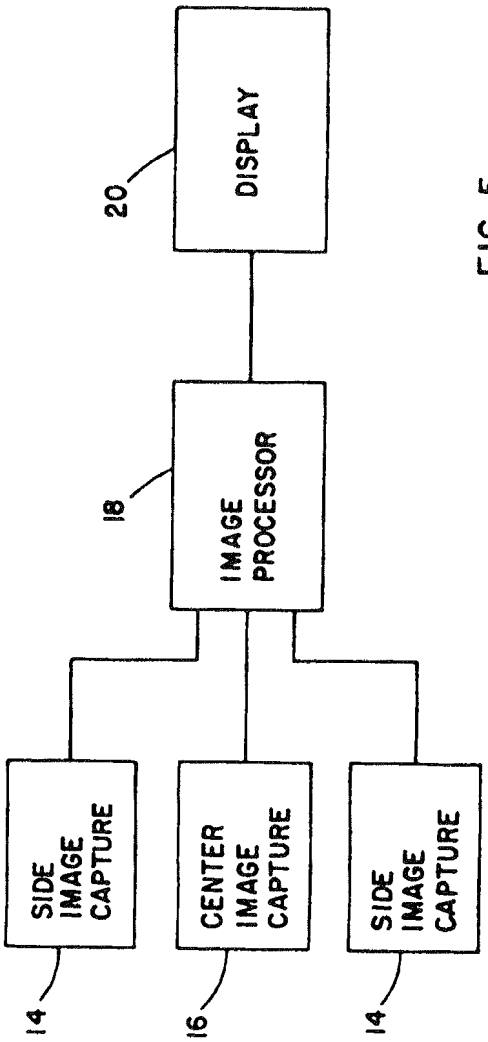

DISPLAY
20
IMAGE PROCESSOR
18
SIDE IMAGE CAPTURE
CENTER IMAGE CAPTURE
SIDE IMAGE CAPTURE
14
16
14

FIG. 5

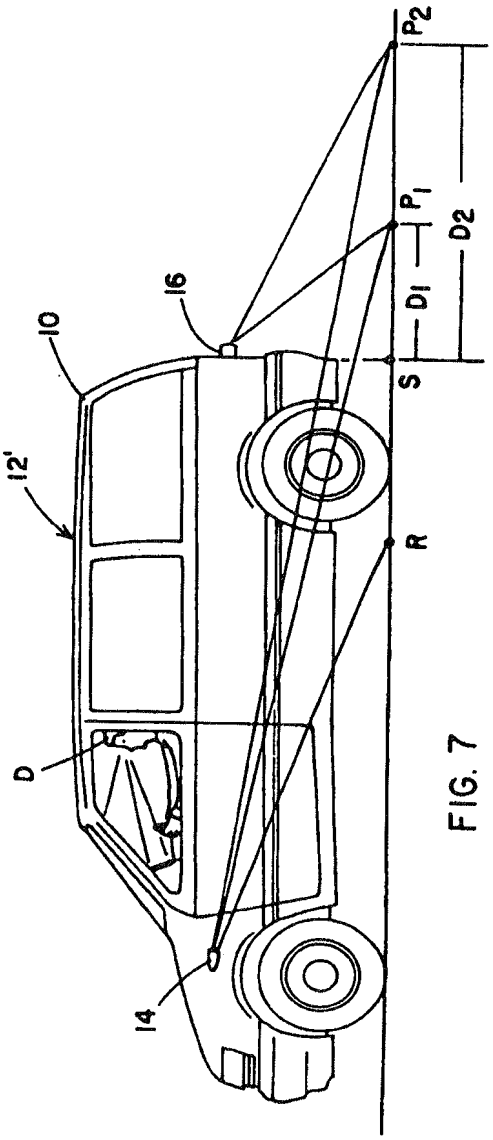


FIG. 7

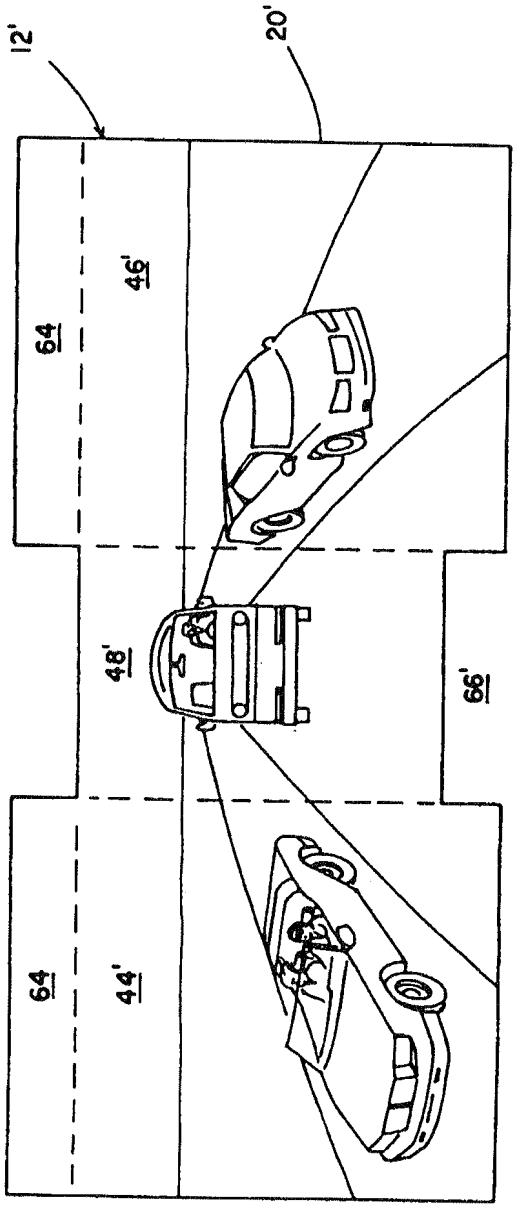


FIG. 8

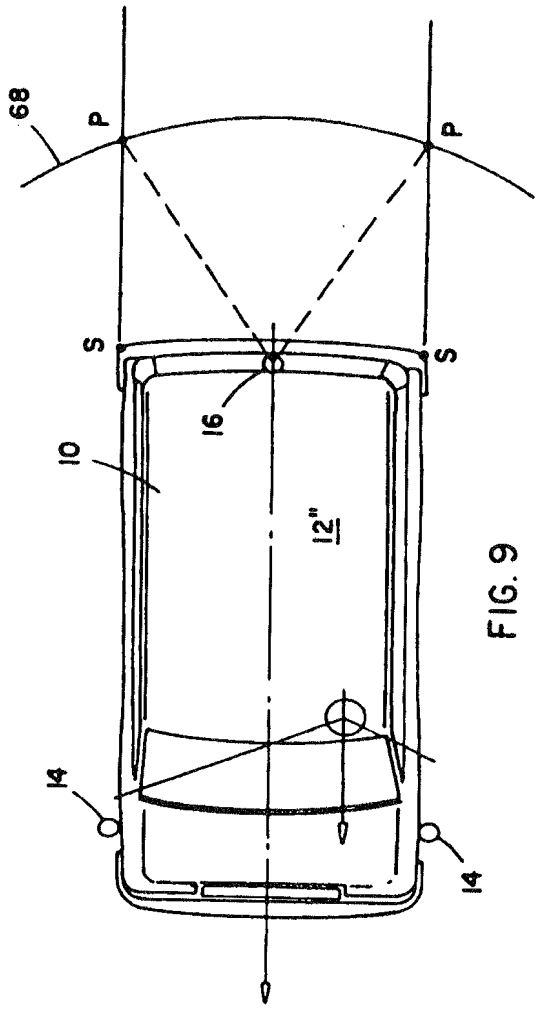

68
P
P
S
S
16
10
12"
14
14

FIG. 9

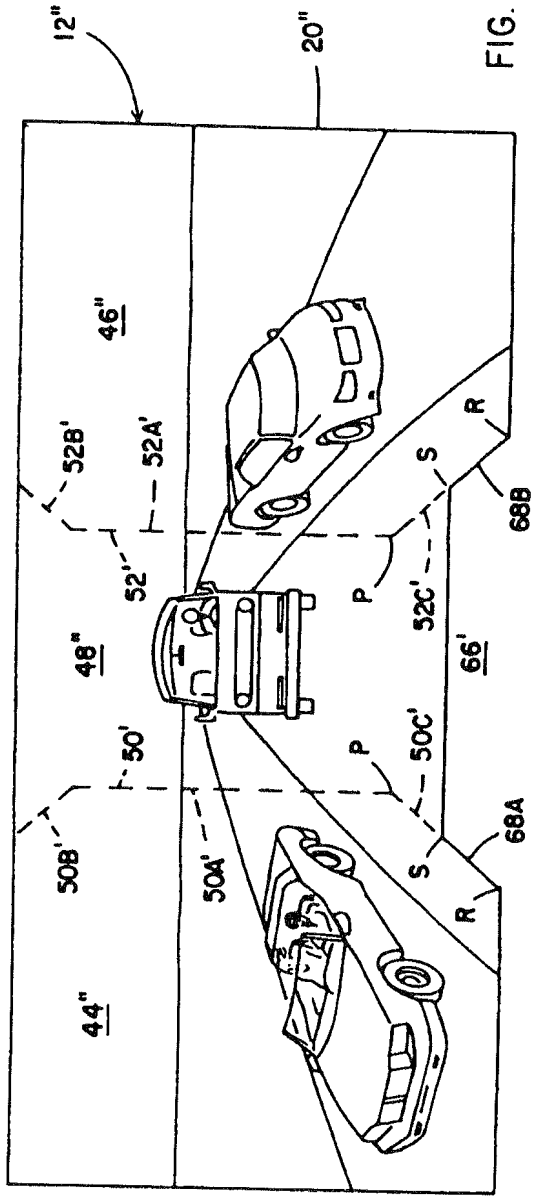

12"
20"
46"
52B'
52A'
S
R
68B
52'
P
52C'
48"
66'
50'
P
50C'
50B'
50A'
S
68A
R
44"

FIG. 10

92 N1	94 N2	92 N1	94 N2	92 N1	94 N2	90 92 N1	94 N2
1	1	45	54	94	146	143	
2	2	46	56	95	149	144	
3	3	47	57	96	151	145	
4	4	48	59	97	154	146	
5	5	49	60	98	156	147	
6	6	50	62	99	159	148	
7	7	51	63	100	162	149	
8	8	52	65	101	164	150	
9	9	53	66	102	167	151	
10	10	54	68	103	170	152	
11	11	55	70	104	172	153	
12	13	56	71	105	175	154	
13	14	57	73	106		155	
14	15	58	74	107		156	
15	16	59	76	108		157	
16	17	60	78	109		158	
17	18	61	79	110		159	
18	19	62	81	111		160	
19	20	63	83	112		161	
20	22	64	85	113		162	
21	23	65	86	114		163	
22	24	66	88	115		164	
23	25	67	90	116		165	
24	26	68	92	117		166	
25	28	69	94	118		167	
26	29	70	95	119		168	
27	30	71	97	120		169	
28	31	72	99	121		170	
29	33	73	101	122		171	
30	34	74	103	123		172	
31	35	75	105	124		173	
32	36	76	107	125		174	
33	38	77	109	126		175	
34	39	78	111	127			
35	40	79	113	128			
36	42	80	115	129			
37	43	81	117	130			
38	44	82	119	131			
39	46	83	121	132			
40	47	84	124	133			
41	49	85	126	134			
42	50	86	128	135			
43	51	87	130	136			
44	53	88	132	137			
		89	135	138			
		90	137	139			
		91	139	140			
		92	142	141			
		93	144	142			

FIG. 11

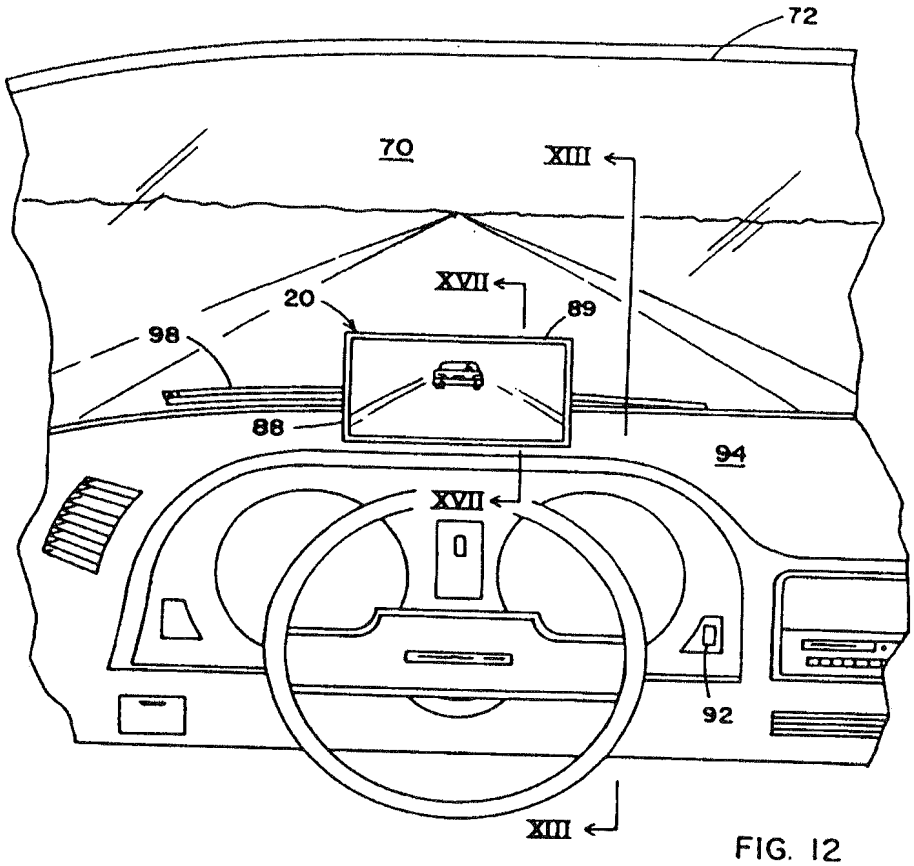

72
70
XIII
XVII
20
89
98
88
94
XVII
92
XIII

FIG. 12

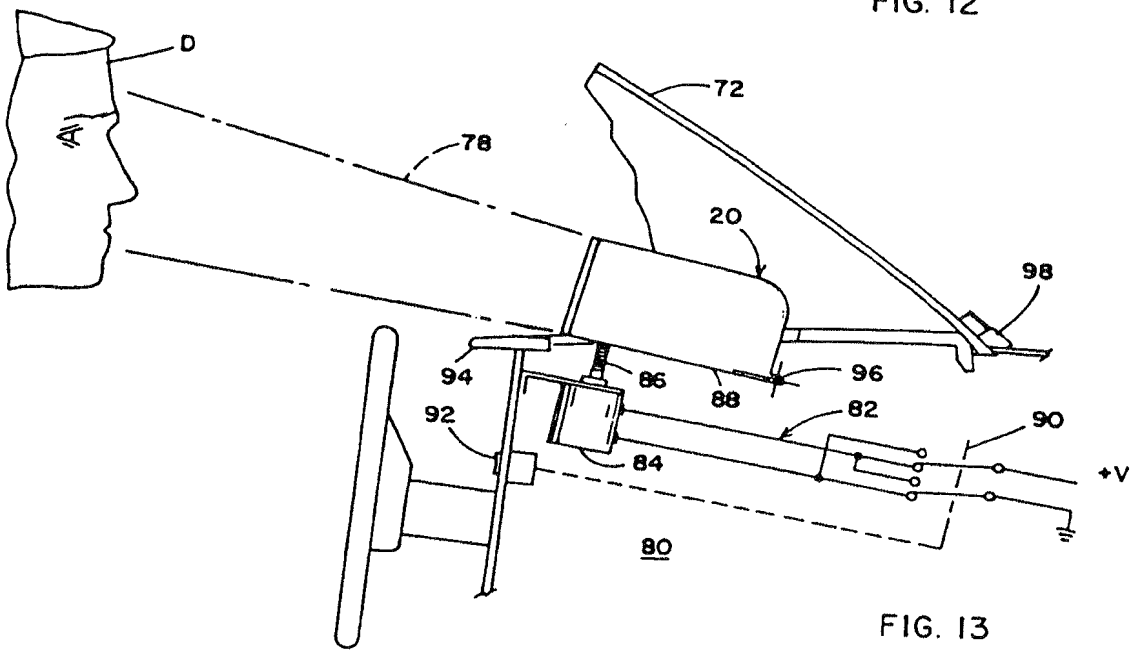

D
A
78
72
20
98
94
86
88
96
92
82
90
84
+V
80

FIG. 13

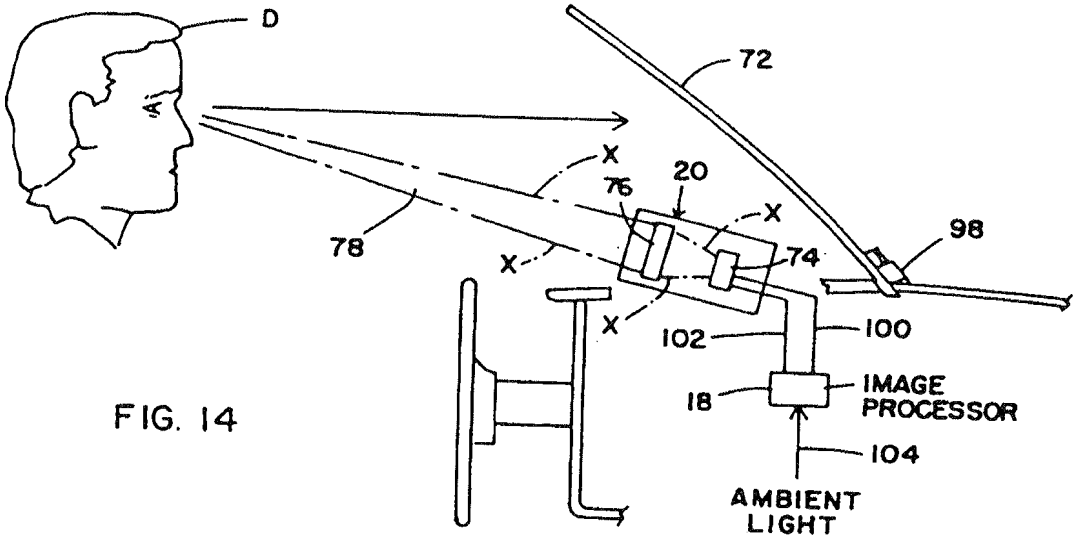


FIG. 14

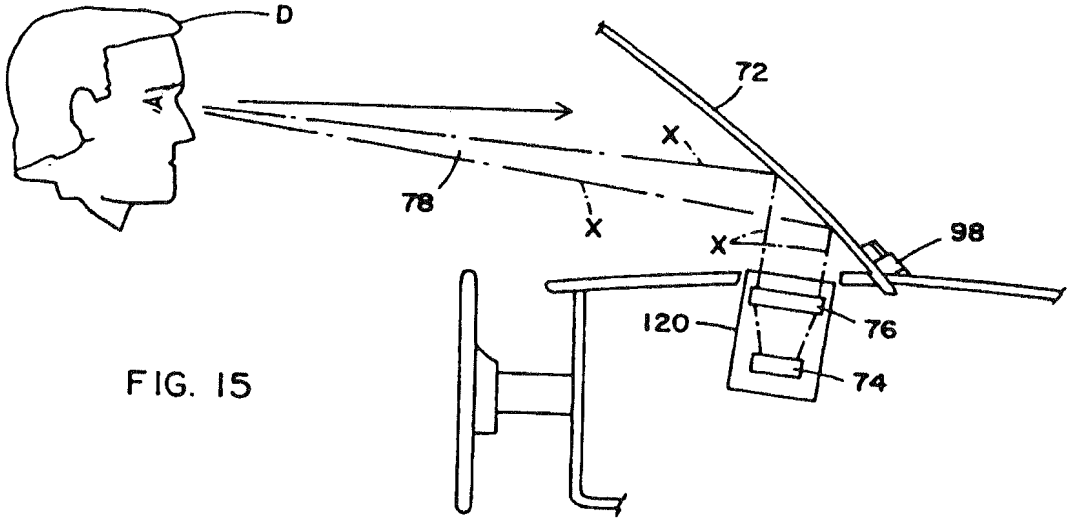


FIG. 15

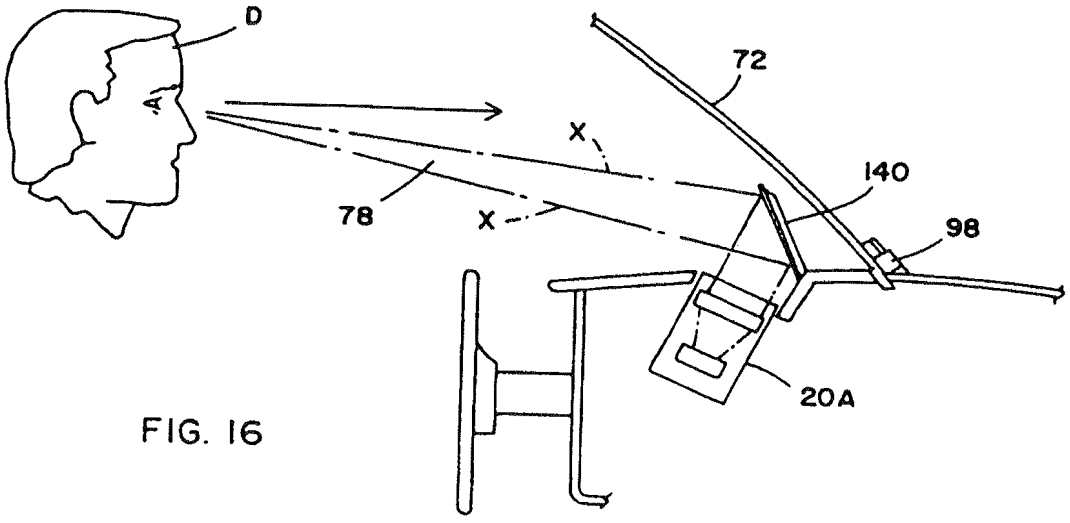
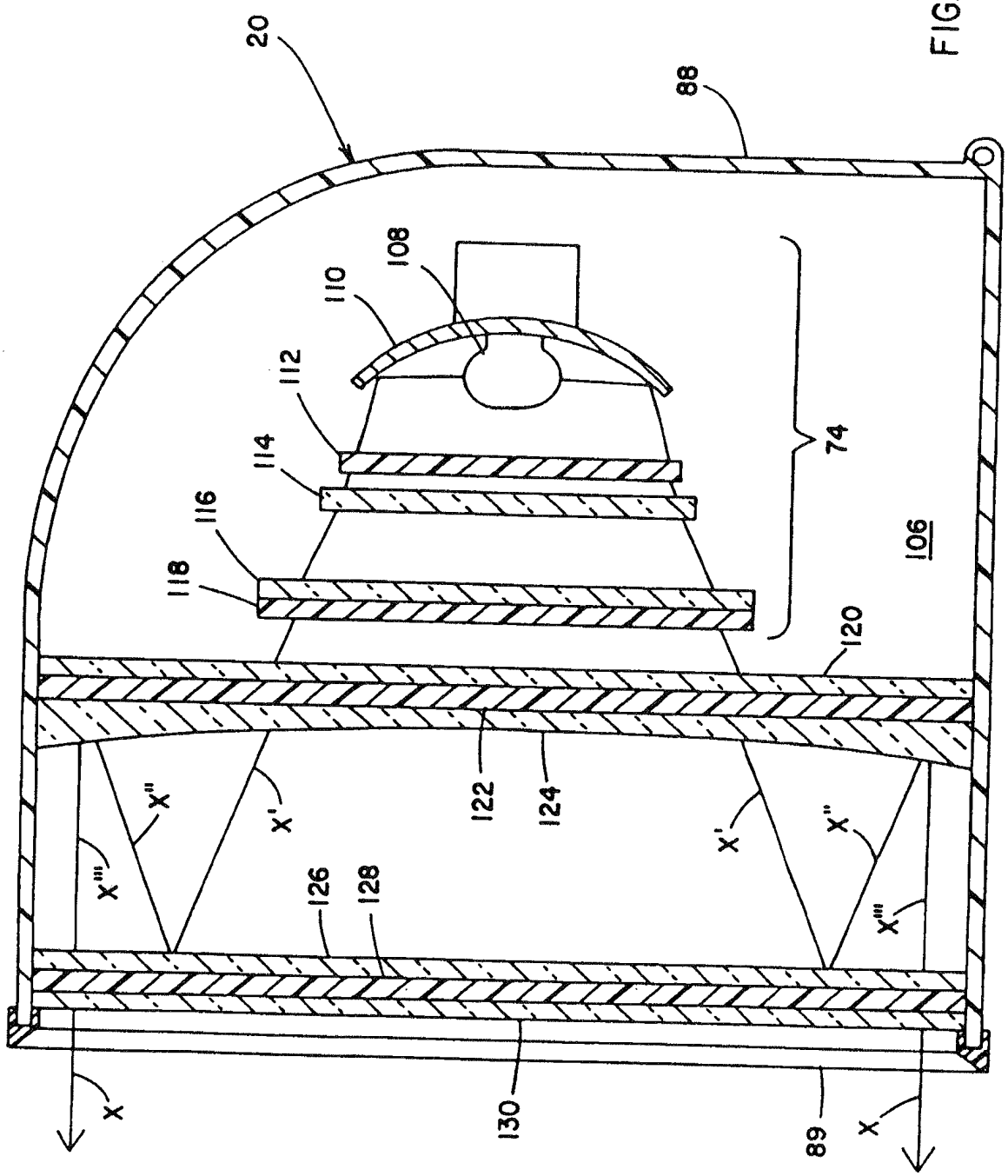


FIG. 16

FIG. 17


20
88
108
110
112
114
116
118
74
106
120
122
124
126
128
130
89
X
X'
X''
X'''

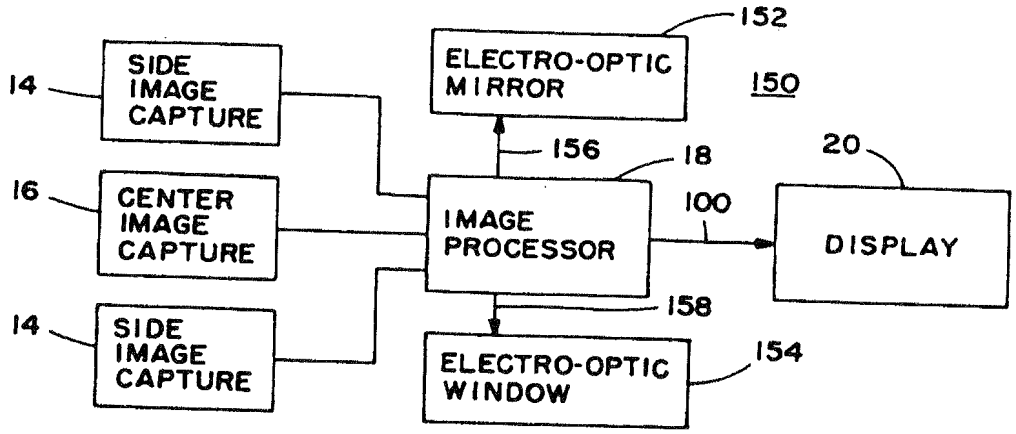


FIG. 18

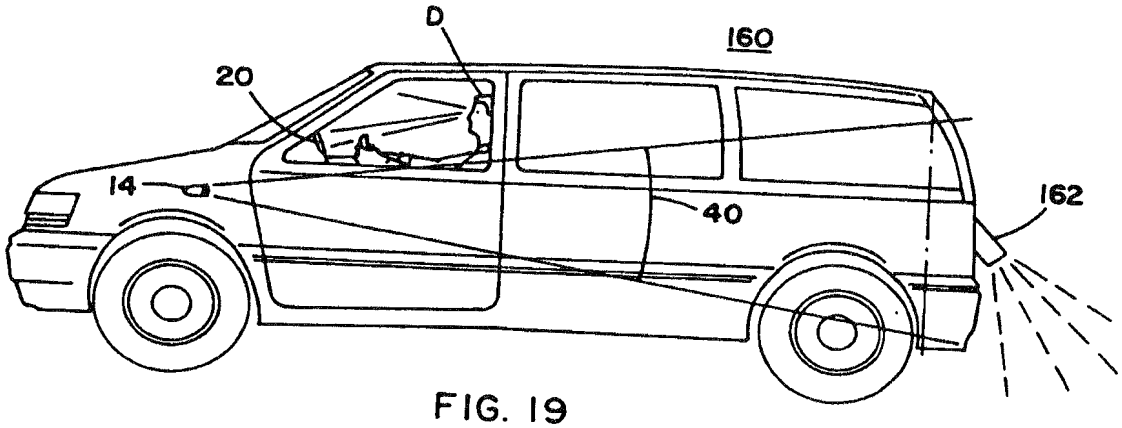


FIG. 19

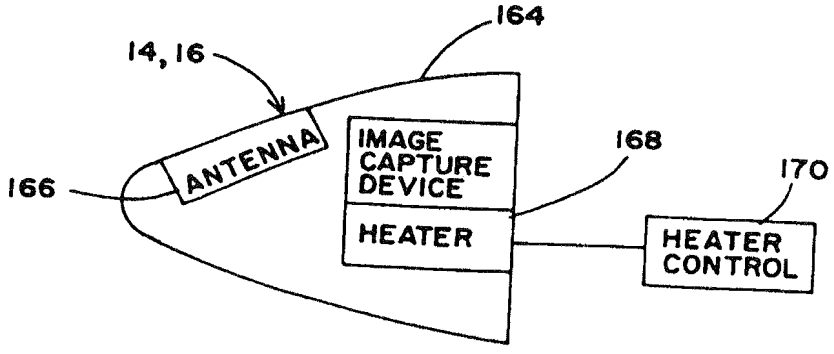


FIG. 20

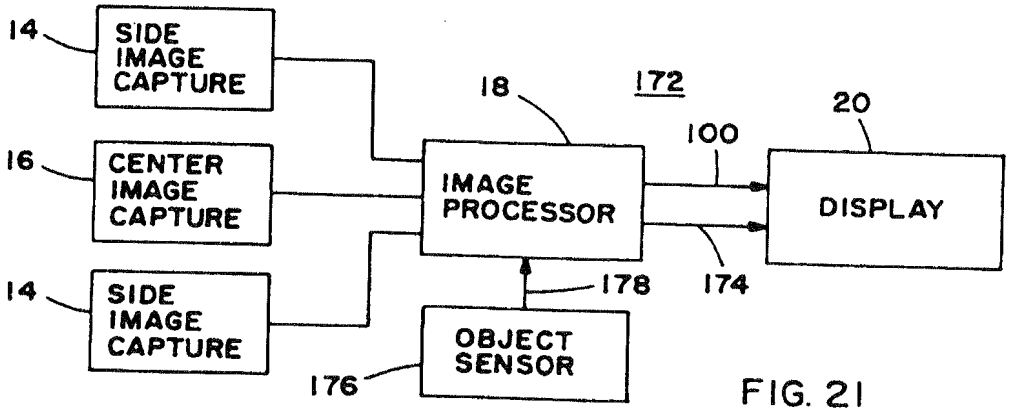


FIG. 21

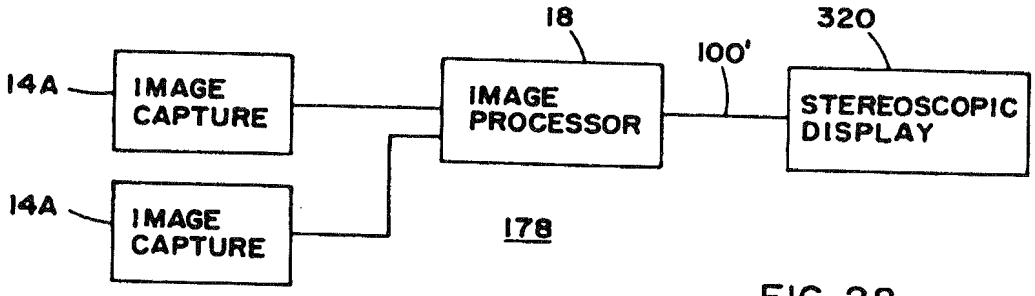


FIG. 22

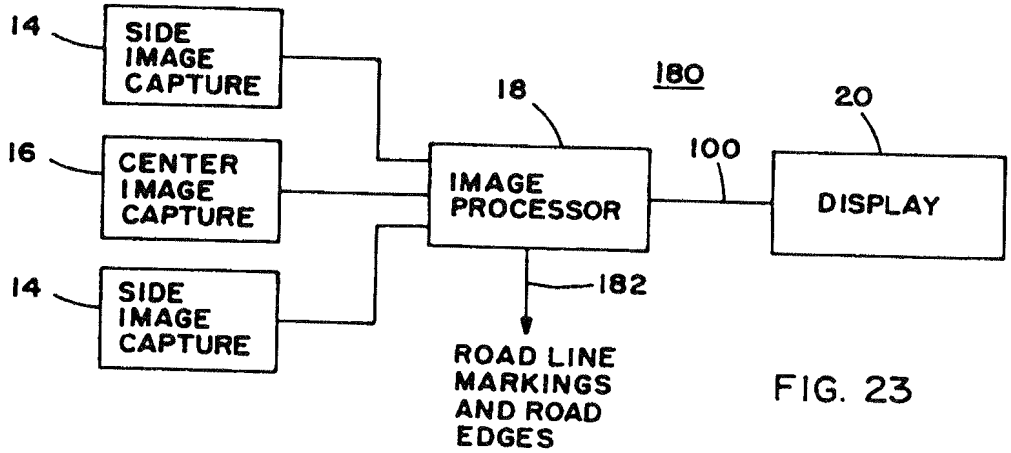


FIG. 23

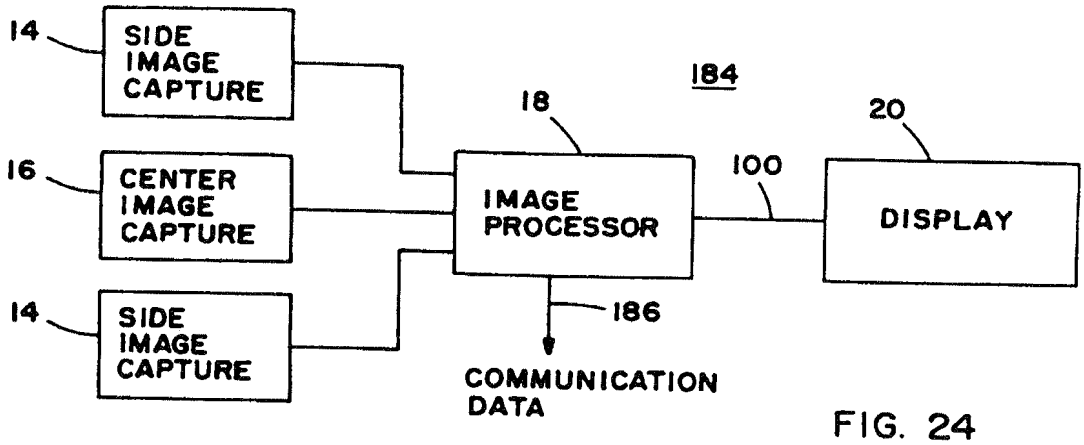
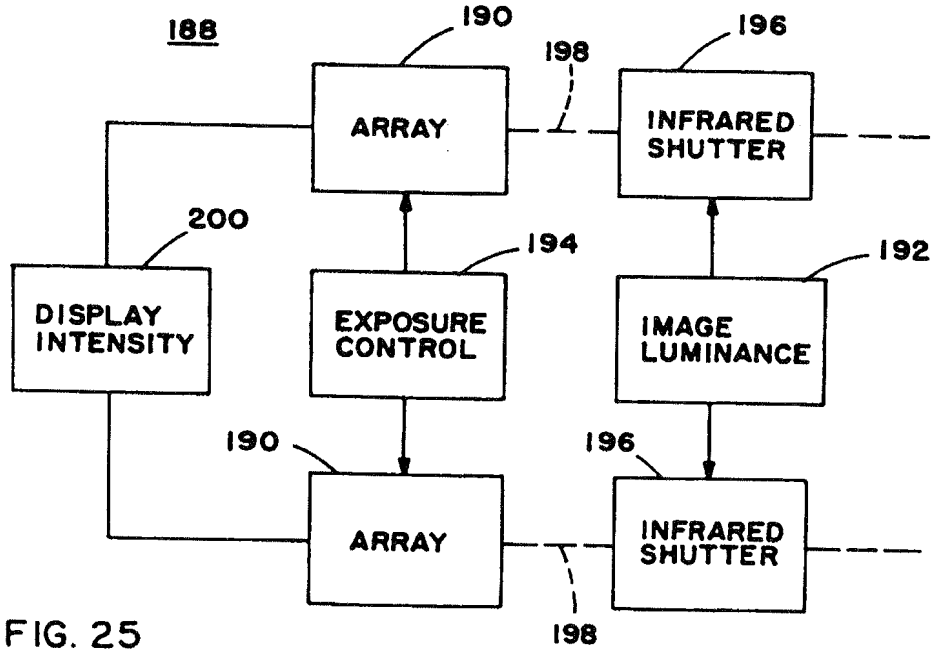

14
SIDE IMAGE CAPTURE
16
CENTER IMAGE CAPTURE
14
SIDE IMAGE CAPTURE
184
18
IMAGE PROCESSOR
100
20
DISPLAY
186
COMMUNICATION DATA

FIG. 24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190
198
196
ARRAY
INFRARED SHUTTER
200
194
192
DISPLAY INTENSITY
EXPOSURE CONTROL
IMAGE LUMINANCE
190
196
ARRAY
INFRARED SHUTTER
198

FIG. 25

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE
First Named Inventor/Applicant Name:	Kenneth Schofield
Filer:	Timothy A. Flory/Amanda Sytsma
Attorney Docket Number:	MAG04 P-2059

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility application filing	1011	1	390	390
Utility Search Fee	1111	1	620	620
Utility Examination Fee	1311	1	250	250
Pages:				
Claims:				
Claims in Excess of 20	1202	66	62	4092
Independent claims in excess of 3	1201	1	250	250
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**5602**

Electronic Acknowledgement Receipt

EFS ID:	15208828
Application Number:	13800691
International Application Number:	
Confirmation Number:	4472
Title of Invention:	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE
First Named Inventor/Applicant Name:	Kenneth Schofield
Customer Number:	15671
Filer:	Timothy A. Flory
Filer Authorized By:	
Attorney Docket Number:	MAG04 P-2059
Receipt Date:	13-MAR-2013
Filing Date:	
Time Stamp:	16:58:53
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$5602
RAM confirmation Number	6443
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Transmittal of New Application	Transmittal.pdf	70428 eba637255455db6d67a0260dedc78e2e9ffa8db9	no	1
Warnings:					
Information:					
2	Miscellaneous Incoming Letter	RequestForContinuation.pdf	36787 2b1d9e2d056592bde4557836d0fc09ed515bdc43	no	6
Warnings:					
Information:					
3	Application Data Sheet	ApplicationDataSheet.pdf	1437582 4dde95f8c9f7dd828fc5c355cf6f50407a590dd0	no	7
Warnings:					
Information:					
4	Oath or Declaration filed	Declaration.pdf	153841 0bb631f23174fb517fbd44bfcc623b2c12a6e86e	no	3
Warnings:					
Information:					
5		Specification.pdf	228051 2562046e16172c19f56705a026fd6ab0b6aa8cb8	yes	58

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	34
Claims	35	57
Abstract	58	58

Warnings:					
Information:					
6	Drawings-only black and white line drawings	P2059Drawings.pdf	1359505 65b6bbff083e35db9da2fde3f025e5cca4420989	no	13
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	37780 8316de045ae5fb9376b487d7ba78f67a6001565f	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	3323974	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/800,691

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	600
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	86 minus 20 =	* 66			OR	x 80 =	5280
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4 minus 3 =	* 1				x 420 =	420
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	7300

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/800,691	03/13/2013	2668	5602	MAG04 P-2059	86	4

CONFIRMATION NO. 4472

15671
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr.
SE, Suite 207
Grand Rapids, MI 49546

FILING RECEIPT

OC000000060473028

Date Mailed: 04/22/2013

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Kenneth Schofield, Holland, MI;
Mark L. Larson, Grand Haven, MI;
Keith J. Vadas, Coopersville, MI;

Applicant(s)

Donnelly Corporation, Holland, MI

Assignment For Published Patent Application

DONNELLY CORPORATION, Holland, MI

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 12/688,146 01/15/2010
which is a CON of 12/496,357 07/01/2009
which is a CON of 11/122,880 05/05/2005 PAT 7561181
which is a CON of 10/324,679 12/20/2002 PAT 6891563
which is a CON of 08/952,026 11/19/1997 PAT 6498620
which is a 371 of PCT/US1996/007382 05/22/1996

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

If Required, Foreign Filing License Granted: 04/15/2013

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/800,691**

Projected Publication Date: 08/01/2013

Non-Publication Request: No

Early Publication Request: No

Title

MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

Preliminary Class

382

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications:

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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NOT GRANTED

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/800,691	03/13/2013	Kenneth Schofield	MAG04 P-2059

CONFIRMATION NO. 4472

15671
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr.
SE, Suite 207
Grand Rapids, MI 49546

NOTICE

OC000000060473029

Date Mailed: 04/22/2013

INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

A new inventor's oath or declaration that identifies this application (e.g., by Application Number and filing date) is required. The inventor's oath or declaration does not comply with 37 CFR 1.63 in that it:

- does not state that the above-identified application was made or authorized to be made by the person executing the oath or declaration.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/800,691	03/13/2013	Kenneth Schofield	MAG04 P-2059

CONFIRMATION NO. 4472

IMPROPER CPOA LETTER

15671
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr.
SE, Suite 207
Grand Rapids, MI 49546

OC000000060473067

Date Mailed: 04/22/2013

NOTICE REGARDING POWER OF ATTORNEY

This is in response to the power of attorney filed 03/13/2013. The power of attorney in this application is not accepted for the reason(s) listed below:

- The power of attorney from the inventors has not been accepted because the power of attorney must be signed by the applicant for patent. See 37 CFR 1.32(b)(4).

/eruga/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/800,691	03/13/2013	Kenneth Schofield	MAG04 P-2059

CONFIRMATION NO. 4472

15671
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr.
SE, Suite 207
Grand Rapids, MI 49546

PUBLICATION NOTICE

OC000000062965683

Title:MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

Publication No.US-2013-0194426-A1
Publication Date:08/01/2013

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PTO/SB/08A (07-05)
Approved for use through 07/31/2006. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet	1	of	17

Complete if Known	
Application Number	13/800,691
Filing Date	March 13, 2013
First Named Inventor	Kenneth Schofield
Art Unit	2486
Examiner Name	Anand Shashikant Rao
Attorney Docket Number	MAG04 P-2059

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		8,224,031	07-17-2012	Saito	
		8,098,142	01-17-2012	Schofield et al.	
		8,095,310	01-10-2012	Taylor et al.	
		8,017,898	09-13-2011	Lu et al.	
		7,930,160	04-19-2011	Hosagrahara et al.	
		7,914,187	03-29-2011	Higgins-Luthman et al.	
		7,881,496	02-01-2011	Camilleri	
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		7,792,329	09-07-2010	Schofield et al.	
		7,720,580	05-18-2010	Higgins-Luthman	
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		7,639,149	12-29-2009	Katoh	
		7,633,383	12-15-2009	Dunsmoir et al.	
		7,619,508	11-17-2009	Lynam et al.	
		7,616,781	11-10-2009	Schofield et al.	
		7,565,006	07-21-2009	Stam et al.	
		7,561,181	07-14-2009	Schofield et al.	
		7,541,743	06-02-2009	Salmeen et al.	
		7,526,103	04-28-2009	Schofield et al.	
		7,459,664	12-02-2008	Schofield et al.	
		7,425,076	09-16-2008	Schofield et al.	
		7,423,248	09-09-2008	Schofield et al	
		7,423,821	09-09-2008	Bechtel et al.	
		7,402,786	07-22-2008	Schofield et al.	
		7,388,182	06-17-2008	Schofield et al.	
		7,380,948	06-03-2008	Schofield et al.	
		7,375,803	05-20-2008	Bamji	
		7,370,983	05-13-2008	DeWind et al.	
		7,360,932	04-22-2008	Uken et al.	
		7,344,261	03-18-2008	Schofield et al.	
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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				Complete if Known	
				Application Number	13/800,691
				Filing Date	March 13, 2013
				First Named Inventor	Kenneth Schofield
				Art Unit	2486
				Examiner Name	Anand Shashikant Rao
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U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
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		7,255,451	08-14-2007	McCabe et al.	
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		7,046,448	05-16-2006	Burgner	
		7,038,577	05-02-2006	Pawlicki et al.	
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Art Unit	2486
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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Complete if Known	
Application Number	13/800,691
Filing Date	March 13, 2013
First Named Inventor	Kenneth Schofield
Art Unit	2486
Examiner Name	Anand Shashikant Rao
Attorney Docket Number	MAG04 P-2059

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Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
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First Named Inventor	Kenneth Schofield
Art Unit	2486
Examiner Name	Anand Shashikant Rao
Attorney Docket Number	MAG04 P-2059

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First Named Inventor	Kenneth Schofield
Art Unit	2486
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		JP04114587	04-15-1992	Matsushita Electric Ind. Co. Ltd.		X
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		JP05213113	08-24-1993	Fujitsu Ten Ltd.		X
		JP0577657	03-30-1993	Fujitsu Ltd.		
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		JP07004170	01-13-1995	Matsushita Electric Ind. Co. Ltd.		X
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First Named Inventor	Kenneth Schofield
Art Unit	2486
Examiner Name	Anand Shashikant Rao
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Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code [3]-Number[4]-Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
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Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation it not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

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Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
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(54) [Title of the Invention] Display Apparatus for Moving Body

(57) [Abstract]

[Purpose] To provide an efficient display apparatus for a moving body, which saves space and provides high visibility as well as is available for multi-purpose use.

[Constitution] In a display apparatus for a moving body, installed in a moving body such as an automobile, vehicle, ship and aircraft, a display drive portion including a power source portion, information memory portion and display control portion is provided to a display housing portion provided with a substantially flat display and a display interface circuit. An attaching portion is provided to the display housing portion so that the display housing portion is movably attached with respect to a fixed portion of the moving body.

[Effect] The display apparatus can be installed easily in a moving body that is subject to a substantial spatial restriction. Easy operation of the display apparatus allows the display apparatus to be seen in an appropriate position and at an appropriate angle. The display portion can also be used for other apparatuses required, which is useful and saves space.

[0002]

[Prior Art] Since many display apparatuses are used for moving bodies of various kinds, such as automobiles, vehicles, ships, and flying objects, the amount of information required is increasing. A display apparatus used for these moving bodies requires high reliability and visibility as well as lightness and compactness. It is also required that, depending on the types of information, display apparatuses or a part thereof can be housed in such a place that the apparatus is not obstructive, when not in use. The above-mentioned types of information may include: maintenance and operation manual for a moving body, maps, charts, traffic information, weather information and other operational information; travel, sightseeing and accommodation guides and other accessory information; television, video and other image information. When the amount of maintenance information is small, indicators like lamps, for example, are used. If the number of lamps used is small, the apparatus can be compact.

[0003]

[Problems to be Solved by the Invention] However, when the amount of information increases or in the case of other information mentioned above, such large amount of information requires a flat display. This kind of display may include a cathode-ray tube (CRT), liquid crystal display (LCD), electro-luminescence (EL), plasma display panel (PDP), vacuum fluorescent display (VFD) and light emitting diode (LED). Among these displays, a CRT, which has a large volume, is disadvantageous to be used for a moving body, comparing with other flat displays. A flat display that incorporates a power source, drive, memory device, operating switch and the like also has a substantial volume.

[0026] FIG. 9 is a schematic drawing to show an example, in which the display apparatus for a moving body according to the embodiment shown in FIG. 8 is applied to an automobile. In this example, the display apparatus is installed in the automobile such that the display housing portion 2 is located inside the windshield, in front of a driver and higher than the driver's eye level. In this case, the display housing portion 2 functions not only as a display portion of the display apparatus but also as a sunshade. The movable display housing portion 2 can be used as a sunshade since the display housing portion 2 occupies a considerably large area,

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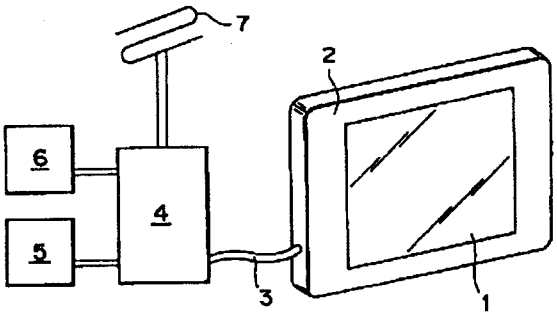
最終頁に続く

(54)【発明の名称】　移動体用表示装置

(57)【要約】
【目的】　空間を節約でき、視認性が良くて、且つ多用途利用が可能な効率の良い移動体用表示装置を提供することである。
【構成】　自動車、車両、船舶、航空機等の移動体に搭載して用いる移動体用表示装置において、フラットディスプレイおよび表示インタフェース回路を設けた全体として偏平な表示ハウジング部に対して、電源部、情報メモリー部、表示制御部等の表示駆動部を設け、表示ハウジング部を移動体の固定部に対して可動なように取り付けるための取付け部を表示ハウジング部に設ける。
【効果】　空間的制約が大きい移動体中に容易に設置することができ、操作性が良く適正な位置および角度で表示を見ることができるようにすることができる。また、表示部が他に必要な装置を兼用することができるので、便利であり空間の節約にもなる。



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【特許請求の範囲】

【請求項1】　自動車、車両、船舶、航空機等の移動体に搭載して用いる移動体用表示装置において、フラットディスプレイおよび表示インタフェース回路を設けた全体として偏平な表示ハウジング部に対して、電源部、情報メモリー部、表示制御部等の表示駆動部を設け、前記表示ハウジング部を前記移動体の固定部に対して可動なように取り付けるための取付け部を前記表示ハウジング部に設けたことを特徴とする移動体用表示装置。

【請求項2】　前記取付け部は、前記表示ハウジング部の一辺に沿って設けられたヒンジである請求項1記載の移動体用表示装置。

【請求項3】　前記取付け部は、前記移動体の前記固定部に取り付けられる軸受け部と、該軸受け部に一端を枢着し他端を前記表示ハウジング部の一端近くに接続した回転軸とを備える請求項1記載の移動体用表示装置。

【請求項4】　前記取付け部は、前記表示ハウジング部の一辺を枢着して前記移動体の前記固定部に取り付けられるパイプであり、前記表示駆動部は、ケーブルガイドと共に前記パイプ内を通した可撓性ケーブルを介して前記表示ハウジング部に接続される請求項1記載の移動体用表示装置。

【請求項5】　前記取付け部は、ユニバーサルジョイントである請求項1記載の移動体用表示装置。

【請求項6】　前記取付け部は、前記移動体の前記固定部に取り付けられるスライド軸受けと、該スライド軸受けに一端を装着し他端を前記表示ハウジング部に接続したスライド軸とを備え、前記表示駆動部は、前記スライド軸を通した可撓性ケーブルを介して前記表示ハウジング部に接続される請求項1記載の移動体用表示装置。

【請求項7】　前記取付け部は、前記移動体の前記固定部に取り付けられるスライド軸受けと、前記表示ハウジング部の一端近くに設けられた回転軸受けと、前記スライド軸受けに一端を装着し他端を前記回転軸受けに枢着させた回転スライド軸とを備え、前記表示駆動部は、前記回転スライド軸を通した可撓性ケーブルを介して前記表示ハウジング部に接続される請求項1記載の移動体用表示装置。

【請求項8】　前記表示ハウジング部には、前記フラットディスプレイと同一面に操作キーが設けられている請求項1から7のうちのいずれかに記載の移動体用表示装置。

【請求項9】　前記表示ハウジング部の厚さは、15㎜以下である請求項1から8のうちのいずれかに記載の移動体用表示装置。

【請求項10】　前記表示駆動部は、前記表示ハウジング部が観視者の視野から離れる位置において表示を消す機能を有する請求項1から9のうちのいずれかに記載の移動体用表示装置。

【請求項11】　前記表示駆動部は、前記移動体が移動中の場合またはその移動速度が規定値以上の場合に表示を消す機能を有する請求項1から10のうちのいずれかに記載の移動体用表示装置。

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【請求項12】　前記表示ハウジング部は、日除け、テーブル、扉、容器の一部のうちの少なくとも一つとして兼用される請求項1から11のうちのいずれかに記載の移動体用表示装置。

【請求項13】　前記フラットディスプレイは、液晶ディスプレイ、プラズマディスプレイ、エレクトロルミネッセンスディスプレイ、発行ダイオードディスプレイのうちの少なくと一つである請求項1から12のうちのいずれかに記載の移動体用表示装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、表示装置に関し、特に、自動車、車両、船舶、航空機等の移動体に搭載して用いる表示装置に関するものである。

【0002】

【従来の技術】各種の移動体、例えば、自動車、車両、船舶および各種の飛翔体等においては、多くの表示装置が利用されており、必要とされる情報量は増加の傾向にある。これら移動体に使用される表示装置は、高信頼性で視認性が良いと共に、軽量コンパクトであることも要求される。また、情報の種類によっては、表示が不必要なとき表示装置あるいはその一部が、邪魔にならない場所に収容できることも要請される。このような情報として、例えば、移動体の保守、操作マニュアル、地図、航路、交通状況、気象状況と言った各種運行に関する情報、旅行、観光、宿泊案内等の付帯情報、テレビ、ビデオ等の映像情報等がある。保守に関するもので情報量が少ない場合、例えば、ランプ等の表示器が使用され、ランプ数が少なければコンパクトな装置として実現されている。

【0003】

【発明が解決しようとする課題】しかしながら、保守情報量が増大したり、前述した他の情報においては、情報量が非常に多いので、平面的な表示機器が必要になる。このような表示機器の例として、ＣＲＴ、液晶（ＬＣＤ）、エレクトロルミネッセンス（ＥＬ）、プラズマディスプレイ（ＰＤＰ）、蛍光表示管（ＶＦＤ）、発光ダイオード（ＬＥＤ）等の各種ディスプレイがある。これら表示機器の内、ＣＲＴは体積が大きく、他のフラットディスプレイと比較して、移動体用には不利である。フラットディスプレイといえども、その電源、駆動装置、メモリー装置や操作スイッチ等を一体に組み込んだ装置にあっては、相当な体積を有するものになる。

【0004】こうした表示装置を移動体中で使用する場合、他の計器や操作装置の邪魔にならないため、設置場所は制限を受け表示が見にくくなる傾向にある。また、フラットディスプレイが、壁面等にはめ込まれて使用さ

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れる例もあるが、これは、表示という単一用途の利用であって効率がよいとは言えない。

【0005】以上説明したように、従来の移動体中での表示装置は、表示情報量が多いと体積も相当に大きくなり、設置位置が制限され表示が見にくかったり、見にくい場合でもその位置を変えることは困難であった。さらに、表示単一用途しか利用されず効率が悪かったので、空間を節約でき、視認性が良くて、且つ多用途利用が可能な効率の良い表示装置が切望されているのが現状である。

【0006】本発明の目的は、これら従来技術の問題点を解消し、空間を節約でき、視認性が良くて、且つ多用途利用が可能な効率の良い移動体用表示装置を提供することである。

【0007】

【課題を解決するための手段】本発明によれば、自動車、車両、船舶、航空機等の移動体に搭載して用いる移動体用表示装置において、フラットディスプレイおよび表示インタフェース回路を設けた全体として偏平な表示ハウジング部に対して、電源部、情報メモリー部、表示制御部等の表示駆動部を設け、前記表示ハウジング部を前記移動体の固定部に対して可動なように取り付けるための取付け部を前記表示ハウジング部に設けたことを特徴とする。

【0008】

【実施例】次に、添付図面に基づいて、本発明の実施例について本発明をより詳細に説明する。

【0009】図1は、本発明の一実施例としての移動体用表示装置の全体の構成を示す概略図である。この移動体用表示装置は、表示部であるフラットディスプレイ1を有する表示ハウジング部2と、この表示ハウジング部2に可撓性ケーブル3を介して接続された表示駆動部とを備えている。この実施例では、表示駆動部は、表示制御部4と、電源部5と、情報メモリー部6と、受信装置7とを備えている。これら各部分は、自動車、車両、船舶、航空機等の移動体の固定部に取り付けられるものである。

【0010】図2に示すように、表示ハウジング部2には、その下辺部にそって、ヒンジ81が取り付けられていて、このヒンジ81を移動体内の適当な固定部に取り付けることにより、表示ハウジング部2は、固定部に対して矢印方向に回動して、観視者の視認し易い位置に固定することができる。また、この表示ハウジング部2には、フラットディスプレイ1と同一面に操作キー9が設置されている。

【0011】フラットディスプレイ1としては、従来使用されている各種のものを使用できる。LCDを除く自発光タイプのものは、照明装置を必要としないので、非発光タイプのものより薄くできて好ましい。LCD、PDPは、現状三原色が利用でき、他のものより好ましい。

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【0012】表示ハウジング部2には、表示インタフェース回路を組み込むのが好ましい。すなわち、情報量が多いフラットディスプレイの端子数は非常に多いので、表示インタフェース回路を表示ハウジング部2の外に設けると、連結するケーブル数も多くなってかさばると共に接続も煩雑となってしまう。この表示インタフェース回路は、ICや各種チップ部品等を使用し、表面実装技術によって薄型に形成することができる。

【0013】また、図2に示すように、表示ハウジング部2に操作キー9を設けると、操作性が良くなると共に、ケーブル数を減らすことができ好ましい。キー操作は、表示を見ながら行なうことが多いので、キーは、表示面とほぼ同一面に形成すると操作性が良いのである。

【0014】図2に示すように、この実施例では、表示ハウジング部2にヒンジ81を設けて表示位置を可変とすることができるようにしているが、表示装置の可動部分としては、少なくとも表示部であるフラットディスプレイ1が含まれなければならない。フラットディスプレイ1は、通常、表示ハウジング部2によって保護されるので、この2者が可動部の基本部となる。表示装置の他の部分、例えば、電源、受信装置、情報の制御およびメモリー装置等やこれらに付随する部品は、適宜可動部から分離するのが好ましい。これにより、可動機構の負担を軽減でき、空間の有効利用が可能となる。以下の説明における可動部としては、前述の基本部を念頭として説明する。

【0015】表示位置としては、観視者の視野中央部で正対する角度が望ましいのであるが、他の装置や設置空間の制約により、理想位置からずれることもある。したがって、可動機構として移動の自由度が大きいものが好ましい。表示部が可動であり、移動自由度が大きければ、望ましい位置で表示でき、表示の必要がないときは、表示部を邪魔とならない場所に移動することができるわけである。

【0016】図2の実施例では、可動機構としてヒンジを利用したのであるが、この種の可動機構に使用できる部品としては、一般に数多くのものが知られており、本発明に適用できる。例えば、ヒンジの他に、後述する実施例の如く、回転軸による一軸回転、スライド軸による直線移動、ユニバーサルジョイント等による多軸回転やバネ、ワイヤー等が利用でき、さらに、これらを組み合わせたものが使用できる。移動の動力としては、モーター、油圧、空圧、バネ等が利用できるが、軽量であれば手動で充分であって、装置が複雑とならないので好ましい。各ジョイント部には、ベアリング軸受け等を使用すると移動が容易となり摩耗が少なく保守が容易である。これら可動部品によって、可動部と固定部が連結される。一軸回転軸やスライド軸を使用するとき、これら軸を表示ハウジング部の一端近くに設置すると、表示の自

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由度が大きく好ましい。

【００１７】可動部が移動する場合、表示は所定位置に固定される必要がある。この固定に使用する部品も、一般に数多くのものが知られ本発明に適用できる。例えば、ネジ、フック、バネ、ピン、磁石等である。スナップピンを表示ハウジング部に一体形成すると便利である。

【００１８】図３は、本発明の別の実施例の移動体用表示装置の表示ハウジング部と可動機構である取付け部とを示す概略図である。この実施例では、表示ハウジング部２の一端近くに回転軸８２の一端が接続されており、回転軸８２の他端は、軸受け８３に枢着されている。この軸受け８３は、移動体の固定部に取り付け固定されるものである。これにより、表示ハウジング部２は、矢印にて示すように回転軸８２を中心として回動自在なものとされている。

【００１９】図４は、本発明のさらに別の実施例の移動体用表示装置の表示ハウジング部と取付け部とを示す概略図である。この実施例では、図３の実施例における回転軸と軸受けとの関係が反対にされていて、回転軸はパイプ８２ａで形成され、パイプ８２ａの一部に開けられた穴から、可撓性ケーブル３がパイプ中に通されている。可撓性ケーブル３には、ケーブルガイド３ａが備えられている。ケーブル３は、表示装置を組み立てるときや、フラットディスプレイ１および表示ハウジング部２を移動させるときに引っ張られ断線し易いので、このようにケーブルガイド３ａを備えるようにするのが好ましく、また、移動軸であるパイプ８２ａ中に通すのが好ましい。これにより、ケーブル３は、剛性の高い移動軸で保護されると共に、移動軸中心部に設置されるので、変形されることが少なく、断線の危険を軽減できる。

【００２０】図４の実施例では、表示ハウジング部２の下辺にそって軸受け８３ａが設けられていて、この軸受け８３ａにパイプ８２ａが枢着された形とされる。パイプ８２ａを移動体の固定部に取り付け固定すれば、表示ハウジング部２は、矢印にて示すように、パイプ８２ａを中心として回動させられるようになる。

【００２１】図５は、本発明のさらに別の実施例の移動体用表示装置の表示ハウジング部と取付け部とを示す概略図である。この実施例では、取付け部としてユニバーサルジョイント８４が用いられている。したがって、この実施例における表示ハウジング部２は、矢印で示すように、あらゆる方向において回動自在なものとされている。

【００２２】図６は、本発明のさらに別の実施例の移動体用表示装置の表示ハウジング部と取付け部とを示す概略図である。この実施例は、可動機構である取付け部を、スライド軸８５とスライド軸受け８６とで構成したものである。表示ハウジング部２は、スライド軸８５の先端部に設けられた止め具１１によって取り付け固定されている。スライド軸受け８６は、移動体の固定部に取り付けられるもので、したがって、表示ハウジング部２は、矢印で示すような方向に直線的に移動させられうるものとされる。可撓性ケーブル３は、スライド軸８５中を通して延びて端部をコネクタ１０ａに結線している。表示ハウジング部２の対応側部には、コネクタ１０ｂが設けられていて、コネクタ１０ａは、そのコネクタ１０ｂに対して着脱自在なものとされている。

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【００２３】このようにフラットディスプレイ１および表示ハウジング部２と可撓性ケーブル３とを着脱可能にすれば、他の表示装置の表示として使用することもできるので便利である。着脱可能部としては、前述したような部分が好ましいのであるが、移動軸やケーブルおよび着脱に関する止め具等を含んでもよい。着脱可能部にケーブルが含まれるときは、ケーブル端もコネクタ構造とすればよい。

【００２４】図７は、本発明のさらに別の実施例の移動体用表示装置の表示ハウジング部と取付け部とを示す概略図である。この実施例では、可動機構である取付け部は、移動体の固定部に取り付けられるスライド軸受け８８と、表示ハウジング部２の一端近くに設けられた回転軸受け８９と、スライド軸受け８８に一端を装着し他端を回転軸受け８９に枢着させた回転スライド軸８７とを備えている。従って、表示ハウジング部２は、矢印にて示すように、直線方向に移動させられたり、回転スライド軸８７を中心として回動させられたりしうる。可撓性ケーブル３は、回転スライド軸８７を通して表示ハウジング部２に接続されている。

【００２５】図８は、本発明のさらに別の実施例の表示ハウジング部と取付け部とを示す概略図である。この実施例では、可動機構である取付け部は、移動体の固定部に取り付けられる軸受け９１と、表示ハウジング部２の上辺にそって設けられた軸受け９２と、直角に曲げられた一端を軸受け９２に枢着し、他端を軸受け９１に枢着した回転軸９０とを備える。従って、表示ハウジング部２は、矢印にて示すように、水平面内および垂直面内の二つの回転方向に回動可能なものとされる。

【００２６】図９は、図８の実施例の移動体用表示装置を自動車に適用した例を示す概略図である。この例は、表示装置の表示ハウジング部２が、自動車のフロントガラスの内側で運転者の前方で目の高さよりも上方に配置されるように、自動車内に搭載した場合である。この場合、表示ハウジング部２は、表示装置の表示部として作用するだけでなく、日除けとしても機能しうるものである。可動部である表示ハウジング部２は、相当な面積を有するので、これを日除けとして利用することもできるのである。

【００２７】図１０は、本発明の移動体用表示装置の表示ハウジング部を自動車の前部座席１２の一部として収納した例を示す概略図である。図１１は、図１０に示す

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収納状態から、表示ハウジング部２を引き出して見やすい角度に移動させた状態を示す図である。図１１に示す状態は、スライド軸９３が手前に引かれ、スライド軸９３の端部に設けられた軸受け９５と、表示ハウジング部２の下方に設置された回転軸９４とでその回動位置に保たれている。なお、表示ハウジング部２の上方両側面とこれと対応する収納部に形成されたスナップピン１３によって、上部は軽く固定されている。このスナップピン１３は、止め具としての用途と共に、回転軸としても機能している。

【００２８】図１２は、図１１の状態からさらにノブ１４を引いて、スナップピン１３を解放し、表示ハウジング部２を手前に回転させた状態を示している。回転部には、表示ハウジング部２がほぼ水平となるように、ストッパー１５が設置されている。図１２の状態では、表示ハウジング部２の表示反対面がテーブルとして利用されうる。このように、表示ハウジング部２は、相当の面積を有し、且つ通常剛性の高いケースとして構成されるので、これをテーブルとしても利用することができるのである。このような用途として、通常、１５㎜以下の厚みの表示ハウジング部とするのが好適である。薄いほど、空間利用の点で有利であるが、表示ハウジング部の薄型化には限界があり、薄すぎると剛性の点で問題が発生する。好適には、５から１０㎜の厚みである。このような厚みの表示ハウジング部は、前述した日除けやテーブルの他、移動体内の容器の一部や扉としても利用可能である。

【００２９】また、本発明の移動体用表示装置の表示駆動部に次のような機能を持たせることもできる。例えば、表示装置の表示ハウジング部のフラットディスプレイが観視者の視野から離れる位置において、その表示を消すようにすれば、消し忘れによるエネルギーの浪費を防ぐことができる。このような機能は、表示ハウジング部の位置や角度検出スイッチ等を設けたり、止め具等をスイッチとして利用して、表示駆動部における電源部を自動的にオフとするようにすることにより可能である。

【００３０】さらに、移動体の運行者にとって運行中必要の少ない情報、例えば、移動体の保守、操作マニュアル、地図、航路、交通状況、気象状況と言った各種運行に関する情報、旅行、観光、宿泊案内等の付帯情報、テレビ、ビデオ等の映像情報等の表示は、運行中邪魔になったり危険ですらある。このため、移動体が移動中あるいは移動速度が規定値以上になった時に、表示を消すような機能を持たせることは、安全運行の点で好ましい。このような機能は、運行操作頻度が多い自動車運行者にとって特に有用である。このような機能は、例えば、自動者の速度計とスイッチとを連動させて、表示装置の表示駆動部の電源部を自動的にオフとするようにすることにより可能である。

【００３１】

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【発明の効果】以上説明したように、本発明の移動体用表示装置を用いれば、空間的制約が大きい移動体中に容易に設置することができ、操作性が良く適正な位置および角度で表示を見ることができるようにすることができると共に、表示が必要でない場合、表示装置の表示部を邪魔にならない別の場所に移動できるので、空間の有効利用が図れる。また、表示部が他に必要な装置を兼用することができるので、便利であり空間の節約にもなる。さらに、表示を自動的に消す機能を付加すれば、エネルギーの浪費を省き、また、より安全な運行を可能にすることができる。さらにまた、本発明の移動体用表示装置は、移動体中で使用され、運行者、運行補助者および同乗者に利用されるものであるが、他の装置等の関係から、より空間的制約の大きい運行者と運行補助者にとってメリットが大である。

【図面の簡単な説明】

【図１】本発明の一実施例としての移動体用表示装置の全体の構成を示す概略図である。

【図２】図１の移動体用表示装置の表示ハウジング部に取付け部としてのヒンジを設けた状態を示す概略図である。

【図３】本発明の別の実施例の移動体用表示装置の表示ハウジング部と可動機構である取付け部とを示す概略図である。

【図４】本発明のさらに別の実施例の移動体用表示装置の表示ハウジング部と取付け部とを示す概略図である。

【図５】本発明のさらに別の実施例の移動体用表示装置の表示ハウジング部と取付け部とを示す概略図である。

【図６】本発明のさらに別の実施例の移動体用表示装置の表示ハウジング部と取付け部とを示す概略図である。

【図７】本発明のさらに別の実施例の移動体用表示装置の表示ハウジング部と取付け部とを示す概略図である。

【図８】本発明のさらに別の実施例の表示ハウジング部と取付け部とを示す概略図である。

【図９】図８の実施例の移動体用表示装置を自動車に適用した例を示す概略図である。

【図１０】本発明の移動体用表示装置の表示ハウジング部を自動車の前部座席の一部として収納した例を示す概略図である。

【図１１】図１０に示す収納状態から、表示ハウジング部を引き出して見やすい角度に移動させた状態を示す図である。

【図１２】図１１の状態からさらにノブを引いて、スナップピンを解放し、表示ハウジング部を手前に回転させた状態を示している。

【符号の説明】

１　フラットディスプレイ
２　表示ハウジング部
３　可撓性ケーブル
３ａ　ケーブルガイド

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4　表示制御部
5　電源部
6　情報メモリー部
7　受信部
9　操作キー
10a、10b　コネクタ
11　止め具
12　前部座席
13　スナップピン
14　ノブ
15　ストッパー
81　ヒンジ
82　回転軸
82a　パイプ

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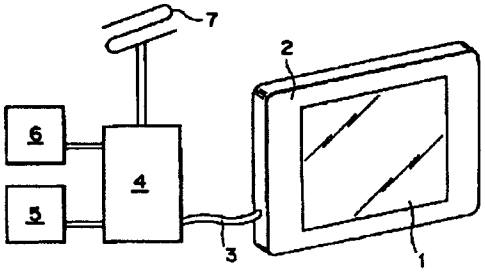
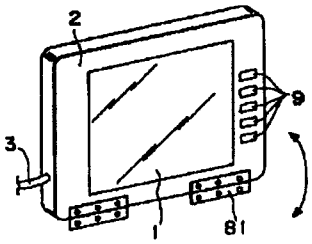
83　軸受け
83a　軸受け
84　ユニバーサルジョイント
85　スライド軸
86　スライド軸受け
87　回転スライド軸
88　スライド軸受け
89　回転軸受け
90　回転軸
91　軸受け
92　軸受け
93　スライド軸
94　回転軸
95　軸受け

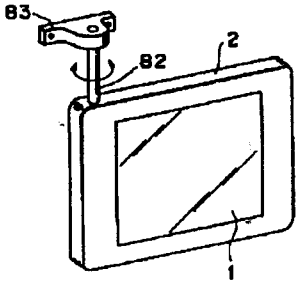
【図1】



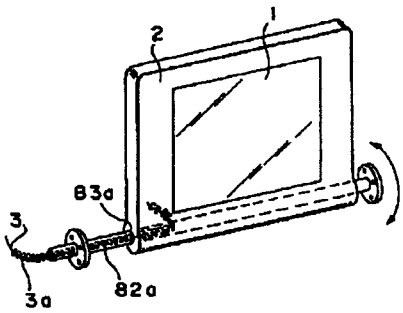
【図2】



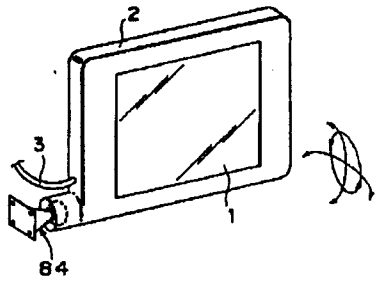
【図3】



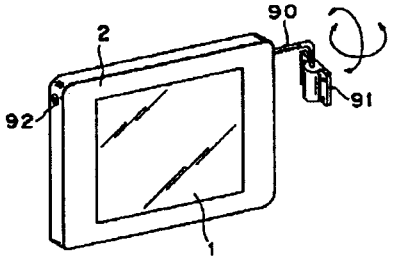
【図4】



【図5】



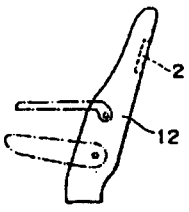
【図8】

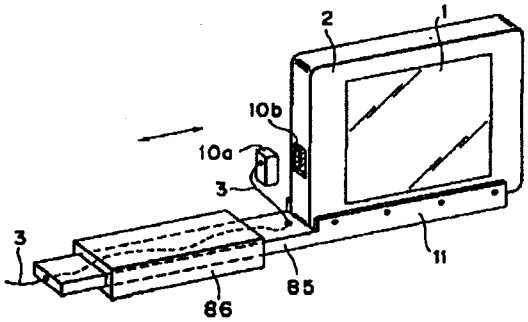


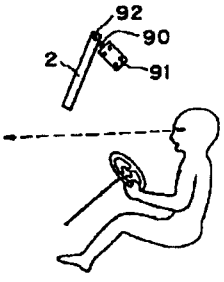
【図9】

【図6】

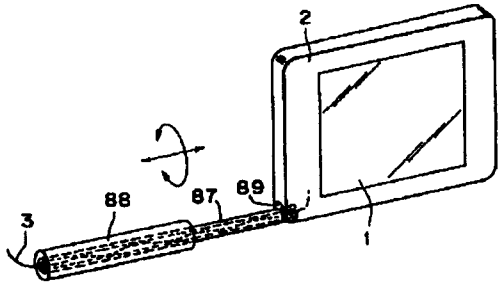
【図10】



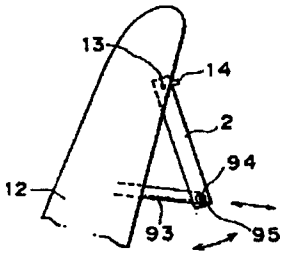




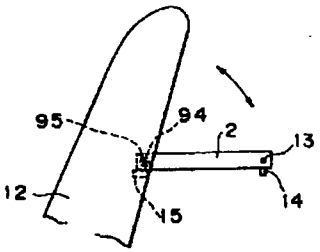
【図７】



【図１１】



【図１２】



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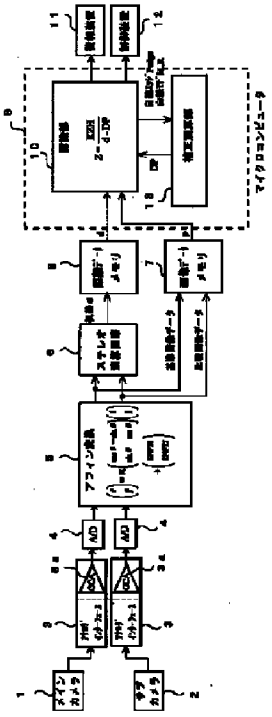
(54)【発明の名称】　監視システムの距離補正装置および距離補正方法

(57)【要約】
【課題】ステレオカメラの水平ずれに起因した誤差を含む視差を補正する。
【解決手段】ステレオ演算回路６は、ステレオカメラより得られた一対の撮像画像に基づいて、ステレオマッチングにより視差を算出する。認識部１０は、視差と消失点視差とに基づいて、対象物までの距離を算出する。補正演算部１３は、一方の撮像画像平面において、距離方向に延在する互いに空間的に平行な複数の近似直線を算出し、この近似直線の交点から第１の消失点を算出するとともに、他方の撮像画像平面において、距離方向に延在する互いに平行な複数の近似直線を算出し、この近似直線の交点から第２の消失点を算出し、第１の消失点と第２の消失点とのずれ量に基づいて、消失点視差を補正する。



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【特許請求の範囲】
【請求項１】監視システムの距離補正装置において、
一対の撮像画像を得るステレオ撮像手段と、
前記ステレオ撮像手段により得られた一対の撮像画像に基づいて、ステレオマッチングにより視差を算出する視差算出手段と、
前記視差算出手段により算出された視差と消失点視差とに基づいて、対象物までの距離を算出する距離算出手段と、
一方の撮像画像平面において、距離方向に延在する互いに空間的に平行な複数の近似直線を算出し、当該近似直線の交点から第１の消失点を算出するとともに、他方の撮像画像平面において、距離方向に延在する互いに平行な複数の近似直線を算出し、当該近似直線の交点から第２の消失点を算出する消失点算出手段と、
前記消失点算出手段により算出された前記第１の消失点と前記第２の消失点とのずれ量に基づいて、前記消失点視差を補正する補正手段とを有することを特徴とする監視システムの距離補正装置。
【請求項２】撮像画像中に写し出された景色から、距離方向に延在する互いに空間的に平行な複数の基準対象物を検出するとともに、撮像画像平面における基準対象物の位置を特定する検出手段をさらに有し、
前記消失点算出手段は、前記検出手段によって複数の基準対象物が検出された場合、当該基準対象物のそれぞれについて撮像画像平面における近似直線を算出することを特徴とする請求項１に記載された監視システムの距離補正装置。
【請求項３】前記基準対象物は、撮像画像に写し出された道路上の左右の車線であることを特徴とする請求項２に記載された監視システムの距離補正装置。
【請求項４】前記基準対象物は、撮像画像に写し出された壁と床との境界を示す左右の境界線であることを特徴とする請求項２に記載された監視システムの距離補正装置。
【請求項５】前記基準対象物は、撮像画像に写し出された線路の左右のレールであることを特徴とする請求項２に記載された監視システムの距離補正装置。
【請求項６】監視システムの距離補正方法において、
同一の景色を同一の時刻に撮像した一対の撮像画像に基づいて、ステレオマッチングにより視差を算出するステップと、
前記視差と消失点視差とに基づいて、対象物までの距離を算出するステップと、
一方の撮像画像平面において、距離方向に延在する互いに空間的に平行な複数の近似直線を算出し、当該近似直線の交点から第１の消失点を算出するステップと、
他方の撮像画像平面において、距離方向に延在する互いに空間的に平行な複数の近似直線を算出し、当該近似直線の交点から第２の消失点を算出するステップと、

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前記第１の消失点と前記第２の消失点とのずれ量に基づいて、前記消失点視差を補正するステップとを有することを特徴とする監視システムの距離補正方法。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、ステレオカメラの位置ずれに起因した誤差を含んだ距離情報を補正する、監視システム用の距離補正装置および距離補正方法に関する。
【０００２】
【従来の技術】近年、ＣＣＤ等の固体撮像素子を内蔵した一対の車載カメラ（ステレオカメラ）を用いたステレオ式車外監視装置が注目されている。三次元計測技術の一つであるステレオ法では、一方の画像におけるある画素ブロックと相関を有する領域を他方の画像において特定する。そして、この画素ブロックの視差、すなわち、双方の画像（ステレオ画像）における画素ブロックの相対的なずれ量に基づき、三角測量の原理を用いて対象物までの距離を算出する。したがって、ステレオマッチングの精度を高めるためには、換言すると、信頼性の高い距離情報を得るためには、視差以外の位置的なずれがステレオ画像に存在しないことが望ましい。しかしながら、実際は、ステレオカメラの機械的な取付精度に起因した位置ずれ（例えば、水平方向や垂直方向への並進ずれ、或いは回転ずれ等）が存在する。この位置ずれのうち、特に、水平方向の並進ずれ（以下「水平ずれ」という）は、ステレオ画像における視差の誤差となって現れるため、それに基づき算出された距離は実測値と異なってしまう。
【０００３】例えば、特開２００１－１６０１３７号公報には、ステレオカメラを用いた監視システムにおいて、ステレオカメラの水平ずれに起因した誤差を含む算出距離を、消失点視差ＤＰを用いて補正する手法が開示されている。この距離補正手法では、一方の撮像画像（基準画像）平面上に写し出された左右の車線の交点から消失点JV2Dを算出し、この消失点JV2Dに基づいて道路面の傾き角度ａを検出する。この傾き角度ａは、消失点JV2Dに基づいて、写真解析の手法を用いて算出される。また、ステレオ処理によって算出された距離画像（算出距離群の二次元的な配列）を用いて、三次元空間における道路面の傾き角度ａ’を検出する。そして、これらの傾き角度ａ，ａ’の差異を求め、両者が一致するように消失点視差ＤＰを補正する。
【０００４】また、特開平６－３４１８３７号公報には、上述した水平ずれの影響の低減を図る車間距離計測装置が開示されている。この計測装置では、自車両前方を撮影することにより得られる一対の撮像画像のそれぞれについて、左右の車線の交点より算出される消失点と、先行車の像の中心軸（対称軸）とを求める。つぎに、一方の撮像画像上における消失点と中心線との視差

を算出するとともに、他方の撮像画像上における消失点と中心線との視差とを算出する。そして、両視差を合計することによって、先行車までの距離を算出する。

【０００５】

【発明が解決しようとする課題】本発明の目的は、ステレオカメラの位置ずれ、特に水平ずれに起因した誤差を含む視差を補正する、新規な距離補正手法を提供することである。

【０００６】また、本発明の別の目的は、補正された視差を用いて対象物までの距離を算出することにより、距離計測の精度の向上を図ることである。

【０００７】

【課題を解決するための手段】かかる課題を解決するために、第１の発明は、一対の撮像画像を得るステレオ撮像手段と、ステレオ撮像手段により得られた一対の撮像画像に基づいて、ステレオマッチングにより視差を算出する視差算出手段と、視差算出手段により算出された視差と消失点視差とに基づいて、対象物までの距離を算出する距離算出手段と、一方の撮像画像平面において、距離方向に延在する互いに空間的に平行な複数の近似直線を算出し、この近似直線の交点から第１の消失点を算出するとともに、他方の撮像画像平面において、距離方向に延在する互いに空間的に平行な複数の近似直線を算出し、この近似直線の交点から第２の消失点を算出する消失点算出手段と、消失点算出手段により算出された第１の消失点と第２の消失点とのずれ量に基づいて、消失点視差を補正する補正手段とを有する監視システムの距離補正装置を提供する。

【０００８】ここで、上記第１の発明において、撮像画像中に写し出された景色から、距離方向に延在する互いに平行な複数の基準対象物を検出するとともに、撮像画像平面における基準対象物の位置を特定する検出手段をさらに設けてもよい。この場合、消失点算出手段は、検出手段によって複数の基準対象物が検出されたならば、検出された基準対象物のそれぞれについて撮像画像平面における近似直線を算出することが好ましい。

【０００９】上記基準対象物は、撮像画像に写し出された道路上の左右の車線であってもよく、撮像画像に写し出された壁と床との境界を示す左右の境界線であってもよい。また、撮像画像に写し出された線路の左右のレールを基準対象物として用いてもよい。

【００１０】第２の発明は、同一の景色を同一の時刻に撮像した一対の撮像画像に基づいて、ステレオマッチングにより視差を算出するステップと、視差と消失点視差とに基づいて、対象物までの距離を算出するステップと、一方の撮像画像平面において、距離方向に延在する互いに空間的に平行な複数の近似直線を算出し、これらの近似直線の交点から第１の消失点を算出するステップと、他方の撮像画像平面において、距離方向に延在する互いに空間的に平行な複数の近似直線を算出し、これらの近似直線の交点から第２の消失点を算出するステップと、第１の消失点と第２の消失点とのずれ量に基づいて、消失点視差を補正するステップとを有する監視システムの距離補正方法を提供する。

【００１１】

【発明の実施の形態】図１は、本実施形態に係るステレオ式車外監視装置の構成を示すブロック図である。ルームミラーの近傍に取付けられたステレオカメラは、通常の走行状態において、自車輌前方の道路や先行車等を含む景色（同一の景色）を同一の時刻で撮像する。このステレオカメラは、ＣＣＤやＣＭＯＳセンサ、或いは、赤外線カメラ等のイメージセンサを内蔵した一対のカメラ１，２で構成されており、各カメラ１，２は、車幅方向において所定のカメラ基線長で取付けられている。基準画像信号を出力するメインカメラ１は、車輌の進行方向に向かって右側に取付けられている。一方、比較画像信号を出力するサブカメラ２は、進行方向に向かって左側に取付けられている。カメラ対１，２は、互いに同期が取れており、同一タイミングで前方の景色を撮像し、２系統のアナログ画像信号を出力する。これらのアナログ画像信号は、後段の回路の入力レンジに合致するように、アナログインターフェース３において調整される。また、アナログインターフェース３中のゲインコントロールアンプ（ＧＣＡ）３ａにおいて画像の明るさバランスが調整される。

【００１２】アナログインターフェース３において調整されたアナログ画像信号は、Ａ／Ｄコンバータ４により、所定の輝度階調（例えば、２５６階調のグレースケール）のデジタル画像データに変換される。デジタル化された各データは、補正回路５においてアフィン変換が施される。各カメラ１，２の位置ずれ、そしてそれに起因したステレオ画像のずれは、画像にアフィン変換を施すことにより等価的に補正される。ここで、「アフィン変換」とは、画像を回転、移動または拡大・縮小する幾何学的な座標変換の総称をいう。補正回路５は、４つのアフィンパラメータＫ，θ，SHFTI，SHFTJを用いて、原画像に対して下式で示した線形変換を施す。

【数１】

$$\begin{pmatrix} i' \\ j' \end{pmatrix} = K \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} i \\ j \end{pmatrix} + \begin{pmatrix} SHFTI \\ SHFTJ \end{pmatrix}$$

【００１３】この数式において、（ｉ，ｊ）は原画像の座標であり、（ｉ’，ｊ’）は変換後の座標である。また、アフィンパラメータSHFTI，SHFTJはそれぞれ、ｉ方向（画像の水平方向）への移動、ｊ方向（画像の垂直方向）への移動を表している。また、アフィンパラメータθ，Ｋはそれぞれθの回転、Ｋ倍の拡大（|Ｋ|＜1の場合は縮小）を示している。ステレオ画像にアフィン変換

を施すことによって、ステレオマッチングの精度を確保する上で重要な「ステレオ画像における水平線の一致」が保証される。なお、補正回路５の詳細なハードウェア構成については、特開平１０－３０７３５２号公報に記述されているので、必要ならば参照されたい。

【００１４】このような画像処理を経て、メインカメラ１の出力信号から、例えば、水平方向が５１２画素、垂直方向が２００画素の画像領域における各画素の輝度値が基準画像データとして得られる。また、サブカメラ２の出力信号から、基準画像と垂直方向長が同じで、基準画像よりも大きな水平方向長を有する比較画像データが得られる（一例として、水平方向が６４０画素、垂直方向が２００画素）。なお、二次元平面である画像のｉ－ｊ座標系は、画像の左下隅を原点として、水平方向をｉ座標軸、垂直方向をｊ座標軸とする（単位は画素）。基準画像データおよび比較画像データは、画像データメモリ７に格納される。

【００１５】ステレオ演算回路６は、基準画像データと比較画像データとに基づいて視差ｄを算出する。視差ｄは、基準画像において、例えば４×４画素の画素ブロック毎に一つ算出されるため、一フレーム分の基準画像全体では最大で１２８×５０個算出され得る。基準画像中の一画素ブロック（以下「対象画素ブロック」という）の視差ｄｉを算出する場合、まず、その対象画素ブロックの輝度特性と相関を有する領域を比較画像において特定する。周知のとおり、ステレオ画像に写し出された対象物までの距離は、ステレオ画像における視差、すなわち、基準画像と比較画像との間における画素ブロックの水平方向のずれ量として現れる。したがって、比較画像中の画素ブロック（以下「比較画素ブロック」という）を探索する場合、対象画素ブロックのｊ座標と同じ水平線（エピポーラライン）上を探索すればよい。ステレオ演算回路６は、このエピポーラライン上を一画素ずつシフトしながら、比較画素ブロック毎に対象画素ブロックとの相関を評価する（ステレオマッチング）。

【００１６】二つの画素ブロックの相関関係は、例えば、周知の相関評価手法であるシティブロック距離を用いて評価することができる。ステレオ演算回路６は、エピポーラライン上に存在する領域（対象画素ブロックと同一面積）毎にシティブロック距離を求め、基本的には、シティブロック距離の値が最小となる領域を対象画素ブロックの相関先として特定する。そして、対象画素ブロックと相関先に係る画素ブロックとの水平方向のずれ量が視差ｄｉとなる。なお、シティブロック距離の算出に関するハードウェア構成および相関先の詳細な決定手法については、特開平５－１１４０９９号公報に開示されているので必要ならば参照されたい。ステレオ演算回路６によって算出された視差ｄは距離データメモリ８に格納される。

【００１７】マイクロコンピュータ９（機能的に捉えた場合、その機能的ブロックである認識部１０）は、画像データメモリ７から基準画像データを読み出し、基準画像中に写し出された対象物（例えば先行車等）を周知の画像認識技術を用いて認識する。また、認識部１０は、距離データメモリ８から読み出した視差ｄを基本パラメータとして、下式に基づいて対象物までの距離Ｚを算出する。

【数２】

$$Z = \frac{KZH}{d - DP}$$

【００１８】同式において、ＫＺＨは所定の定数（カメラ基線長／水平視野角）であり、ＤＰは消失点視差である。本実施形態において、消失点視差ＤＰは視差補正値（可変）であり、その値は後述する補正演算部１３において算出される。

【００１９】また、認識部１０は「道路形状の認識」を行う。ここで、「道路形状の認識」とは、三次元的な道路形状を左右の車線（白線や追い越し禁止ライン等）に関する関数で表現し、この関数の各パラメータを、実際の道路形状（直線、カーブ曲率または起伏）に合致するような値に設定することである。なお、以下の説明では、車線の典型である白線を例に説明するが、追越し車線等を含めた各種車線に対しても適用可能である。以下、本実施形態における白線モデルの算出手法を図２を参照しつつ説明する。

【００２０】まず、基準画像において白線エッジＰedge、すなわち、水平方向の輝度エッジ（隣接画素間の輝度の変化量が大きい箇所）の内、白線に起因して生じたものが特定される。白線エッジＰedgeは、走行路の左側と右側とについて別個に探索され、複数の左白線エッジＰedge1と複数の右白線エッジＰedge2とがそれぞれ特定される。具体的には、下記の３つの条件を具備する輝度エッジが白線エッジＰedgeとして認識される。

【００２１】（白線エッジの３条件）

１．輝度変化量が所定値以上である輝度エッジで、かつ、輝度エッジの内側（画像中央側）の画素よりも外側（画像端側）の画素の方が輝度が大きいこと

すなわち走行路の左右の白線に起因した白線エッジＰedgeは、図２に示したように、白線の内側の境界（白線と舗装路との境界）における輝度エッジである。

【００２２】２．条件１を満たす白線エッジＰedgeの候補に関して、それと同一水平線上の外側にさらに輝度エッジが存在し、かつ、この輝度エッジの外側の画素よりも内側の画素の方が輝度が大きいこと

白線は所定の幅を有しているため、白線エッジＰedgeの外側にも境界が存在する。この条件は、このような白線の特徴に鑑みて設けられたものである。

【００２３】３．条件１を満たす白線エッジＰedgeを含む画素ブロックに関して、視差ｄが算出されていること

白線エッジＰedgeが存在する箇所に視差ｄが算出されて

いなければ、その白線エッジPedgeは道路形状を認識するのに有効な情報とはならない。

【００２４】認識部１０は、特定された白線エッジPedge毎に、その座標（ｉ，ｊ）およびその視差ｄを下記の数式３および数式４に示した周知の座標変換式に代入することにより、その実空間上の座標（Ｘ，Ｙ，Ｚ）を算出する。

【数３】

$$Y = CAH - Z(JV - j)\,PWV$$

【数４】

$$X = \frac{r}{2} + Z(IV - i)\,PWH$$

【００２５】ここで、定数ＣＡＨはステレオカメラ１，２の取付高さ、定数ｒはステレオカメラ１，２の取り付け間隔、定数ＰＷＶ，ＰＷＨはそれぞれ１画素当たりの垂直視野角、水平視野角である。また、定数ＩＶ，ＪＶはそれぞれ予め設定された消失点Ｖのｉ座標値、ｊ座標値である。また、自車輌の位置を基準に設定された実空間の座標系は、ステレオカメラ１，２の中央真下の道路面を原点として、車幅方向をＸ軸、車高方向をＹ軸、車長方向（距離方向）をＺ軸とする。撮像画像に写し出された対象物（先行車、立体物、または道路等）に関して、画像平面上の座標（ｉ，ｊ）および視差ｄが特定されると、数式２～数式４に示した変換式に基づいて、実空間上の座標（Ｘ，Ｙ，Ｚ）を一義的に特定することができる。

【００２６】このようにして特定された各白線エッジPedgeの実空間上の座標（Ｘ，Ｙ，Ｚ）に基づいて白線モデルが特定される。白線モデルは、認識範囲（例えばカメラ位置から車輌前方８４ｍ先まで）内の左右の白線エッジPedge1，Pedge2のそれぞれ関して所定区間ごとに近似直線を求め、これを折れ線状に連結して表現したものである。一例として示す図３の白線モデルは、認識範囲を７つの区間に分けて、各区間における左右の白線エッジPedge1，Pedge2毎に最小二乗法を用いて下式の直線で近似している。

【数５】（左白線モデルＬ）

$X = a_L \cdot Z + b_L$

$Y = c_L \cdot Z + d_L$

（右白線モデルＲ）

$X = a_R \cdot Z + b_R$

$Y = c_R \cdot Z + d_R$

【００２７】これらの白線モデルＬ，Ｒは、道路のカーブ曲率を表現したカーブ関数（Ｘ＝ｆ(Ｚ)）と、道路の勾配や起伏を表現した勾配関数（Ｙ＝ｆ(Ｚ)）とで構成されている。したがって、実空間における道路の三次元的な変化状態は、左右の白線モデルＬ，Ｒによって把握することができる。認識部１０により算出された各白線エッジPedgeおよび左右の白線モデルＬ，Ｒは補正演算部１３に伝達される。

【００２８】認識部１０は、先行車や道路形状に関する認識結果に基づいて、警報が必要と判定した場合、モニタやスピーカー等の警報装置１１を作動させてドライバーに注意を促す。また、必要に応じて制御装置１２を制御することにより、ＡＴ（自動変速機）のシフトダウンやエンジン出力の抑制、或いはブレーキの作動といった車輌制御が実行される。

【００２９】つぎに、本実施形態にかかる視差補正の詳細を、図４および図５に示すフローチャートを参照しながら説明する。補正演算部１３は、このフローチャートに示した一連の手順に従って消失点視差ＤＰの値を更新し、その値を認識部１０にフィードバックする。なお、このフローチャートは、所定期間のサイクル毎に繰り返し実行される。

【００３０】まず、ステップ１において、補正演算部１３は、認識部１０において算出された一対の撮像画像（基準画像および比較画像）のそれぞれに関して、白線エッジPedgeと白線モデルＬ，Ｒとを読み込む。つぎに、ステップ２において、基準画像において左右の白線が存在するか否かが判断される。これは、認識部１０において左右の白線モデルＬ，Ｒが算出されているかを調べることにより判断することができる。また、左白線エッジPedge1と右白線エッジPedge2とが算出されているか否かを調べることにより判断してもよい。

【００３１】ステップ２において否定判定された場合、すなわち左右の双方に白線が存在しない場合は、互いに平行な線分を抽出できないので消失点を算出することができない。したがって、制御の安定性を図るため、消失点視差ＤＰの現在値を変更することなくリターンへ進み、今回のサイクルにおける本フローチャートの実行を終了する。一方、ステップ２において肯定判定された場合は、ステップ３に進む。

【００３２】ステップ３において、左右の白線の信頼性が評価される。具体的には以下の２つの点が評価される。そしてステップ４において白線として信頼できると判断された場合のみステップ５に進む。一方、白線として信頼できないと判断された場合は、消失点視差ＤＰの値を変更することなくリターンへ進む。

【００３３】（白線の信頼性評価）

１．前回のサイクルにおける白線位置と今回のサイクルにおける白線位置とのずれが所定値よりも大きい場合は白線としての信頼性が低いと判断する。具体的には、従前のサイクルで検出された白線エッジPedgeの位置と今回のサイクルで検出された白線エッジPedgeの位置的が大きくずれている場合には白線としての信頼性が低いと判断する。

【００３４】２．白線がどのくらい先まで見えているかを検証する。白線は少なくともある程度の長さを有している。したがって、フレーム間の白線の推移も考慮して、白線エッジPedgeが奥行き方向において一定の長さ

以上延在していない場合には白線としての信頼性が低いと判断する。

【００３５】ステップ５において、白線モデルR，Lに基づいて、白線の直線性が評価される。正確な消失点を算出するためには、その算出ベースとなる左右の白線が直線的に延在している必要があり、カーブした白線からは正確な消失点を算出することができない。そこで、ステップ６において白線が直線であると判断された場合のみステップ７へ進み、それ以外の場合は、消失点視差ＤＰの値を変更することなくリターンへ進む。

【００３６】白線の直線性は、例えば、認識部１０において算出された白線モデル（カーブ関数Ｘ＝ｆ(Ｚ)）に基づいて評価することができる。図３を参照しながら説明すると、まず、Ｚ－Ｘ平面における所定の距離レンジ（例えば０～Z2）におけるカーブ関数の傾きＡ１（左右の白線Ｌ，Ｒの傾きa_L，a_Rの平均）を算出する。この傾きＡ１は、第１区間における傾きａ1と第２区間における傾きａ2との平均値を用いる。つぎに、その先の所定の距離レンジ（例えばZ2～Z4）におけるカーブ関数の傾きＡ２を算出する。この傾きＡ２は、第３区間における傾きａ3と第４区間における傾きａ4との平均値を用いる。そして、傾きＡ１と傾きＡ２との差（絶対値）を求め、この差が所定のしきい値以下であれば白線が直線であると判断する。

【００３７】図５に示すステップ７以降の手順は、消失点視差ＤＰの更新処理に関する。まず、ステップ７において、基準画像における所定の距離レンジ（例えば０～Z2）内に存在する複数の左白線エッジPedge1の近似直線Ｌ１ｍが、最小自乗法により算出される（図６参照）。同様に、その距離レンジ内に存在する複数の右白線エッジPedge2の近似直線Ｌ２ｍも最小自乗法により算出される。そして、ステップ８において、図６に示したように近似直線Ｌ１ｍ，Ｌ２ｍの交点を特定することで、基準画像における消失点Ｖｍ（ＩＶｍ，ＪＶｍ）のｉ座標値ＩＶｍが算出される。

【００３８】続くステップ９において、基準画像の場合と同様の手法で、比較画像における所定の距離レンジ（例えば０～Z2）内に存在する複数の左白線エッジPedge1の近似直線Ｌ１ｓが最小自乗法により算出される。それとともに、所定の距離レンジ内に存在する複数の右白線エッジPedge2の近似直線Ｌ２ｓも最小自乗法により算出される。そして、ステップ１０において、近似直線Ｌ1ｓ，Ｌ２ｓの交点を特定することで、比較画像における消失点Ｖｓ（ＩＶｓ，ＪＶｓ）のｉ座標値ＩＶｓが算出される。

【００３９】そして、ステップ１１において、これらの消失点ＩＶｍ，ＩＶｓに基づいて、視差補正値、すなわち消失点視差ＤＰの更新処理が行われる。基本的には、基準画像側に関して算出された消失点Ｖｍのｉ座標値ＩＶｍと、比較画像側に関して算出された消失点Ｖｓのｉ座標値ＩＶｓとのずれ量が、消失点視差ＤＰになる。そして、算出された消失点視差ＤＰが認識部１０に対して出力され、今回のサイクルにおける本フローチャートの処理が終了する。なお、制御の安定性を考慮して、このステップ１１で算出された消失点視差ＤＰを１～ｎ回の処理サイクルに亘って保存し、その平均値を距離補正に使用するパラメータ（消失点視差）として適用してもよい。

【００４０】本実施形態によれば、消失点視差ＤＰに関するフィードバック調整を監視制御と並行して行うことで、ステレオカメラの水平ずれが生じた場合であっても常に精度の高い距離を算出することができる。したがって、経年変化や衝撃等によってステレオカメラの取付け位置が初期設定状態から変化した場合であっても、信頼性の高い距離情報を安定して得ることができる。そして、このような算出距離に基づいて監視制御を行うことにより、車外監視の信頼性の向上を図ることができる。特に、本実施形態によれば、一対の撮像画像を用いて消失点視差ＤＰを直接的に検出するため、消失点視差が大きくずれた場合でも、それを安定して検出することができる。

【００４１】なお、上述した説明において、消失点視差の更新は、比例制御や統計制御等によって行ってもよい。例えば、消失点視差ＤＰの１０００サンプル分のヒストグラムを取り、その最頻値を用いてもよい。

【００４２】（撮像画像を用いた各種監視システムへの適用）上述した実施形態では、撮像画像に写し出された道路上の左右の車線（白線）を利用して、消失点視差ＤＰを算出する手法について説明した。これは、自動車の前方監視の場合、通常、距離方向（Ｚ方向）に向かって延在する車線が道路の左右に存在し、これらは空間的に互いに平行であることが多いという一般的な傾向に鑑みたものである。本明細書では、車線のように、距離方向に向かって互いに平行に延在し、消失点算出のベースとなる直線的な対象物を「基準対象物」という。そして、本発明は、「基準対象物」が写し出される撮像画像を用いた各種監視システムに広く適用することができる。

【００４３】一例として、撮像画像に基づき周囲の状況を認識する屋内ロボットに適用する場合、壁と床との２つの境界線を「基準対象物」として用いることができる。図７は、屋内ロボットにおける撮像画像の一例である。なお、同図に示す直線Ｌ１（またはＬ２）は、基準画像側の直線Ｌ１ｍ（またはＬ２ｍ）と比較画像側の直線Ｌ1ｓ（またはＬ2ｓ）とを総称する意味で用いている。通常、左壁と床との境界線および右壁と床との境界線は、距離方向（奥行方向）に向かって互いに平行に延在していることが多い。したがって、左右の境界線を利用して、消失点補正や距離補正を行うことができる。以下、境界線を利用した消失点の調整手順の概略を説明する。

【００４４】まず、基準画像に基づき複数の直線Ｌ１ｍ，Ｌ２ｍを検出する。上述した（白線エッジの条件）と同様に、壁と床との境界部分の輝度エッジや視差に関する条件を予め設定しておく。そして、撮像画像において、この条件に合致する部分を境界線として認識し、その直線性を適宜評価した上で、それぞれの近似直線Ｌ１ｍ，Ｌ２ｍを算出する。また、別の手法としては、周知のハフ変換等を用いて、撮像画像において直線を形成する点（境界部分のエッジ画素）を抽出することにより、「基準対象物」となる直線Ｌ１ｍ，Ｌ２ｍを算出してもよい。

【００４５】つぎに、距離画像に基づき直線Ｌ１ｍ，Ｌ２ｍが空間的に概ね平行であることを判定する。上述したように、距離画像に基づいて、直線Ｌ１ｍ，Ｌ２ｍを構成する各領域の実空間上の位置を特定することができる。したがって、２本の直線Ｌ１ｍ，Ｌ２ｍが検出された場合、周知の手法を用いて、これらの直線Ｌ１ｍ，Ｌ２ｍの空間的な平行性を判定する。

【００４６】直線Ｌ１ｍ，Ｌ２ｍが空間的に平行である場合、基準画像におけるこれらの交点より、消失点Ｖｍを算出する。同様の手法で、比較画像における直線Ｌ１ｓ，Ｌ２ｓを検出し、比較画像におけるこれらの交点より消失点Ｖｓを算出する。そして、これらの消失点Ｖｍ，Ｖｓのｉ座標値の差異から消失点視差ＤＰを算出する。

【００４７】また、他の例として、鉄道車両の前方状況を監視するシステムに適用する場合、左右のレールを「基準対象物」として用いることができる。図８は、鉄道車両前方の撮像画像の一例である。左右のレールは、距離方向に向かって互いに平行に延在している。したがって、左右のレールを「基準対象物」として用いることで２本の平行な直線Ｌ１，Ｌ２を特定できるため、上述した手法で消失点視差ＤＰを調整することが可能となる。

【００４８】

【発明の効果】このように本発明では、距離情報等の三次元情報を算出する際に用いられる消失点視差を、一対の撮像画像平面上における平行な近似直線の交点として算出された消失点のずれに基づいて補正している。したがって、ステレオカメラの位置ずれが生じた場合であっても、それに起因した誤差を相殺するような消失点視差値が自動的に算出されるため、精度の高い三次元情報（距離情報）を安定して得ることができる。

【図面の簡単な説明】

【図１】ステレオ式車外監視装置の構成を示すブロック図

【図２】基準画像の白線エッジの説明図

【図３】白線モデルを示す図

【図４】視差補正手順の一部を示すフローチャート

【図５】図４に続く手順を示したフローチャート

【図６】撮像画像平面上における消失点の算出説明図

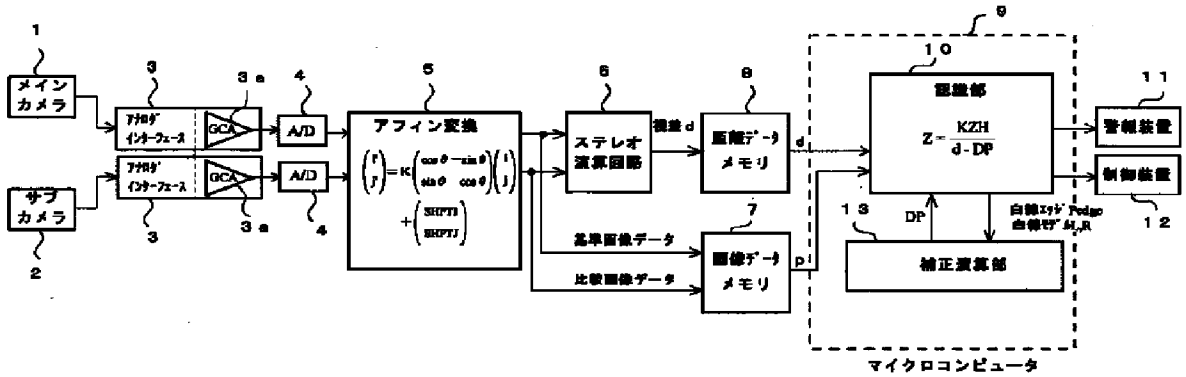
【図７】屋内ロボットの撮像画像の一例を示す図

【図８】鉄道車両前方の撮像画像の一例を示す図

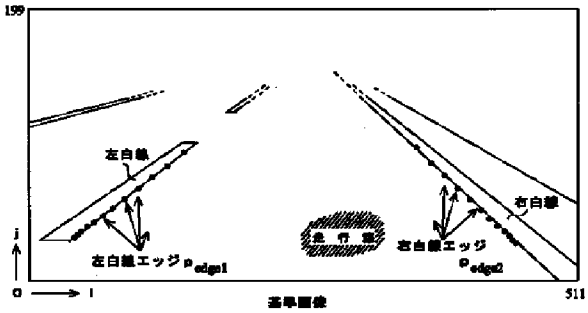
【符号の説明】

１　メインカメラ
２　サブカメラ
３　アナログインターフェース
３ａ　ゲインコントロールアンプ
４　Ａ／Ｄコンバータ
５　補正回路
６　ステレオ演算回路
７　画像データメモリ
８　距離データメモリ
９　マイクロコンピュータ
１０　認識部
１１　警報装置
１２　制御装置
１３　補正演算部

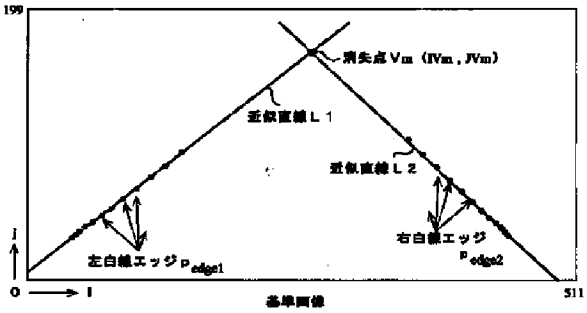
【図１】



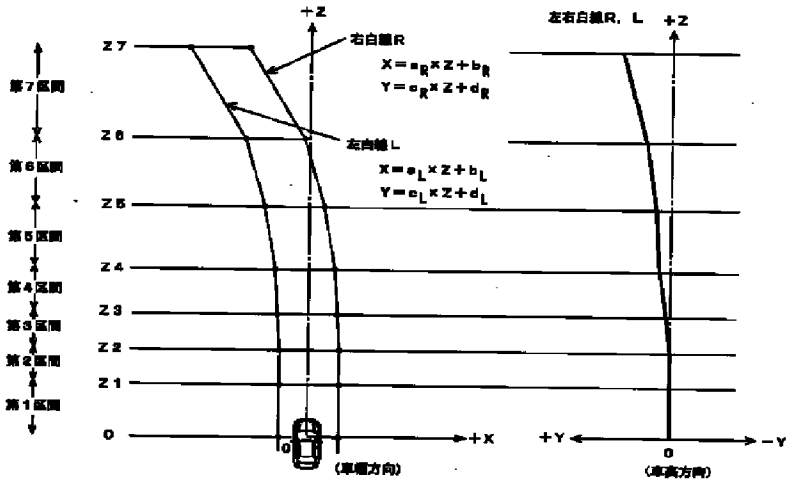
【図２】


199
左白線
左白線エッジ p_{edge1}
走行路
右白線エッジ p_{edge2}
右白線
j
0
i
511
基準画像

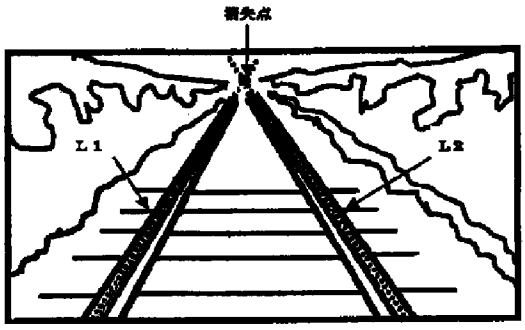
【図６】


199
消失点 Vm (IVm , JVm)
近似直線Ｌ１
近似直線Ｌ２
左白線エッジ p_{edge1}
右白線エッジ p_{edge2}
j
0
i
511
基準画像

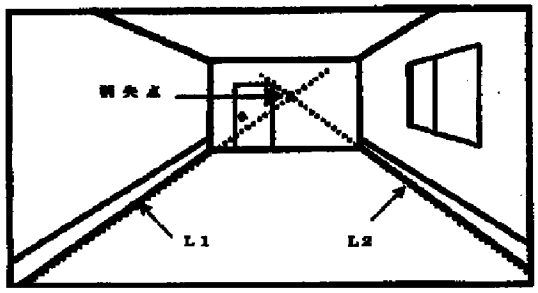
【図３】


+Z
Z7
Z6
Z5
Z4
Z3
Z2
Z1
0
第7区間
第6区間
第5区間
第4区間
第3区間
第2区間
第1区間
右白線R
$X=a_R \times Z+b_R$
$Y=c_R \times Z+d_R$
左白線L
$X=a_L \times Z+b_L$
$Y=c_L \times Z+d_L$
+X
(車幅方向)
左右白線R, L
+Z
+Y
−Y
0
(車高方向)

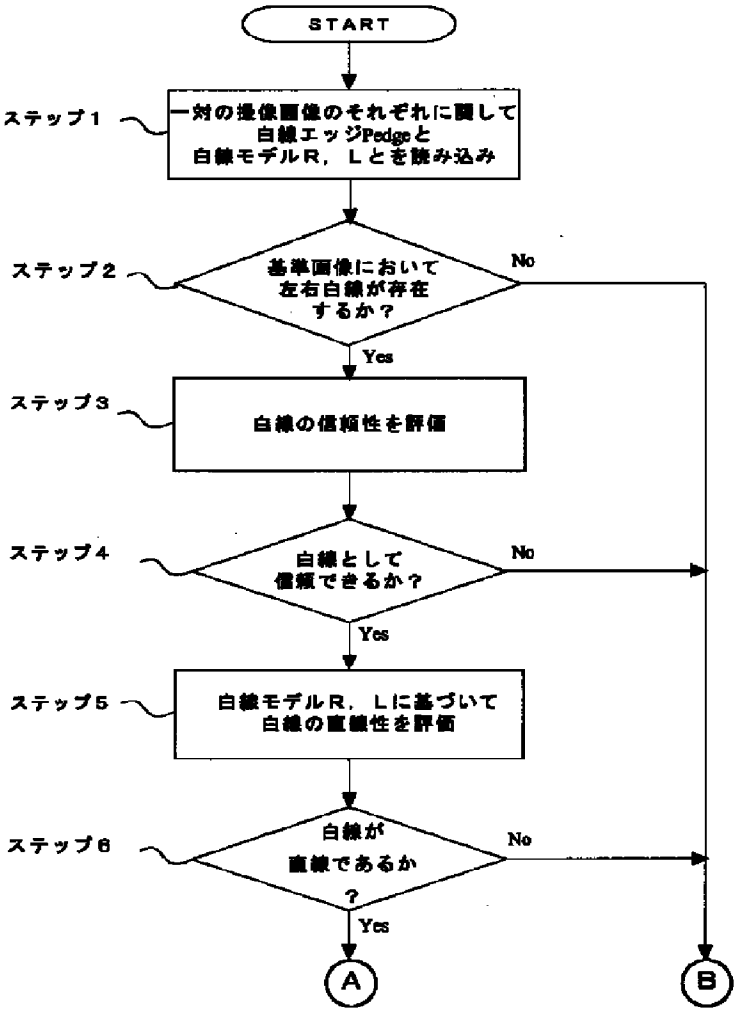
【図８】


消失点
Ｌ１
Ｌ２

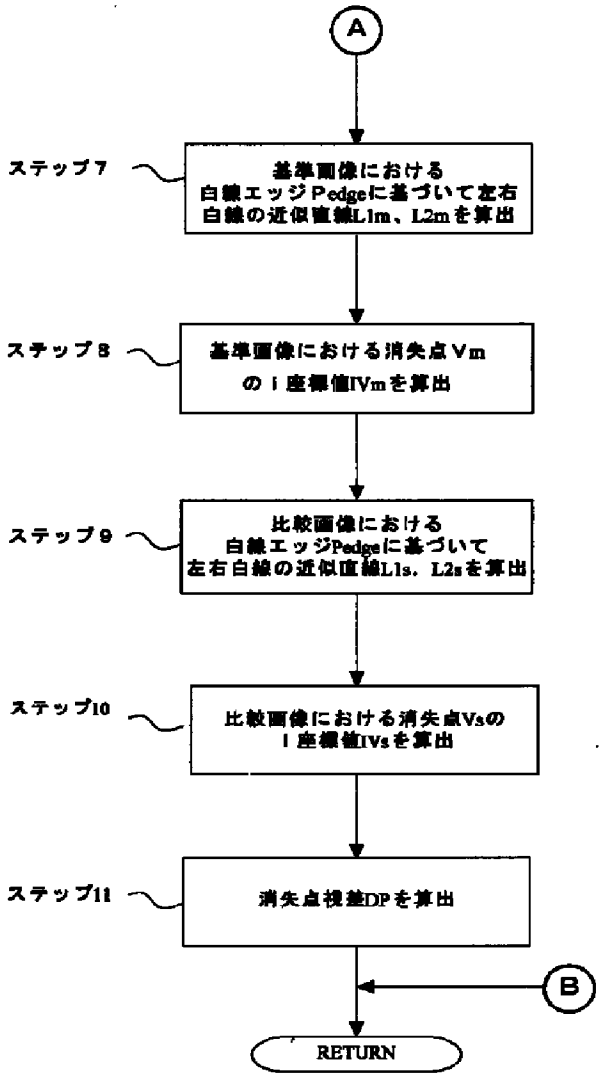
【図７】


消失点
Ｌ１
Ｌ２

【図４】


START
ステップ１
一対の撮像画像のそれぞれに関して
白線エッジPedgeと
白線モデルR，Lとを読み込み
ステップ２
基準画像において
左右白線が存在
するか？
No
Yes
ステップ３
白線の信頼性を評価
ステップ４
白線として
信頼できるか？
No
Yes
ステップ５
白線モデルR，Lに基づいて
白線の直線性を評価
ステップ６
白線が
直線であるか
？
No
Yes
A
B

【図５】



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(51)Int.Cl.⁷		識別記号	FI		テーマコード（参考）
Ｂ６０Ｒ	21/00	６２７	Ｂ６０Ｒ	21/00	６２７　５Ｌ０９６
Ｇ０１Ｂ	11/02		Ｇ０１Ｂ	11/02	Ｈ
Ｇ０６Ｔ	1/00	３１５	Ｇ０６Ｔ	1/00	３１５
		３３０			３３０Ａ
	7/00	３００		7/00	３００Ｅ
	7/60	１５０		7/60	１５０Ｄ
Ｇ０８Ｇ	1/16		Ｇ０８Ｇ	1/16	Ｃ
Ｈ０４Ｎ	7/18		Ｈ０４Ｎ	7/18	Ｊ

Ｆターム(参考)　2F065 AA22 CC40 FF04 FF05 JJ03
JJ26 QQ03 QQ08 QQ13 QQ18
QQ21 QQ24 QQ29 QQ31 QQ38
SS09
2F112 AC03 AC06 BA06 CA04 CA05
FA07 FA21 FA25 FA35 FA45
5B057 AA19 BA13 CA13 CA16 CB12
CB16 DA07 DA08 DB03 DC02
DC05 DC16 DC32
5C054 AA01 AA05 CA04 CC02 CH01
EA01 EA05 FA02 FD01 HA30
5H180 CC04 CC24 CC30 LL02 LL06
5L096 BA02 CA05 FA06 FA09 FA13
FA46 FA66 FA69 HA08 JA18

PAT-NO: JP02003083742A
DOCUMENT-IDENTIFIER: JP 2003083742 A
TITLE: DISTANCE CORRECTION APPARATUS AND METHOD OF MONITORING SYSTEM
PUBN-DATE: March 19, 2003

INVENTOR-INFORMATION:

NAME	COUNTRY
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ASSIGNEE-INFORMATION:

NAME	COUNTRY
FUJI HEAVY IND LTD	N/A

APPL-NO: JP2001277998
APPL-DATE: September 13, 2001

INT-CL (IPC): G01C003/06 , B60R021/00 , G01B011/02 , G06T001/00 , G06T007/00 , G06T007/60 , G08G001/16 , H04N007/18

ABSTRACT:

PROBLEM TO BE SOLVED: To correct parallax including an error caused by the horizontal deviation of a stereo camera.

SOLUTION: A stereo arithmetic circuit 6 calculates parallax by stereo matching based on a pair of imaging images obtained by a stereo camera. A recognition section 10 calculates the distance to a target based on the parallax and a null. A correction operation section 13 calculates a plurality of approximation straight lines that are extended in a distance direction and are parallel one another spatially in one imaging image plane, calculates the first null from the intersection point of the approximation straight lines, at the same time calculates a plurality of approximation straight lines that are extended in a distance direction and are parallel one another on the other imaging image plane, calculates the second null from the intersection point of the approximation straight lines, and corrects the null parallax based on the amount of deviation between the first and second nulls.

⑲日本国特許庁（JP）　⑪実用新案出願公開

⑫公開実用新案公報（U）　昭62－72245

⑤1Int.Cl.⁴	識別記号	庁内整理番号
B 60 R 21/00		D－2105－3D
1/00		7443－3D
G 08 B 5/22		6810－5C
G 08 G 1/16		6821－5H
H 04 N 7/18		J－7245－5C

⑬公開　昭和62年(1987)5月8日

審査請求　未請求　（全　頁）

⑤4考案の名称　車両用後方監視装置

⑳実　願　昭60－164073

㉒出　願　昭60(1985)10月28日

⑦2考案者　小祝　秀明　横浜市磯子区新杉田町8番地　株式会社東芝横浜金属工場内

⑦1出願人　株式会社東芝　川崎市幸区堀川町72番地

⑦4代理人　弁理士　則近　憲佑　外1名

明　細　書

1. 考案の名称

車両用後方監視装置

2. 実用新案登録請求の範囲

車両の後部に載置されこの車両の後方を撮像するビデオカメラと、車両の運転席近傍に載置され前記ビデオカメラにより撮像された映像を映し出すモニタテレビと、前記ビデオカメラの前面に設けられ部分的に板厚を変えて広角撮像を可能とした透明板とを具備したことを特徴とする車両用後方監視装置。

3. 考案の詳細な説明

〔考案の技術分野〕

本考案は車両用後方監視装置に係り、特にビデオカメラとモニタテレビを用いた車両用後方監視装置に関する。

〔考案の技術的背景〕

大型トラックやバスのように運転席からの自動車後方の視野が大きく制限されている場合に、従来は安全確認のために第7図または第8図に示す

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ような方法が用いられていた。すなわち、第7図に示すように車両1の後部上方1aに大形の凸面鏡2を設けて車両後部の広い範囲の視野を反射させて、運転席1bの近傍に設けられたバックミラー3に映し出す。または第8図に示すように車両1の後部上方1aにビデオカメラ4を設置して自動車後方の至近距離を撮像し、このビデオカメラ4からの映像信号を運転席1b近くに設けられたモニタテレビ5に映し出す方法が用いられていた。

〔背景技術の問題点〕

しかしながら第7図に示すように大形凸面鏡2を用いてバックミラー3に車両後方の映像を映し出す場合、運転席1bから被写体までの距離が長いためなどで被写体が小さく見え、十分確認することが困難であった。また第8図に示すようにビデオカメラ4を使う場合には、監視したい場所をズームアップして確認できる長所はあるが、標準レンズのみの場合は視野角が狭く、車両の周囲の状況を十分に把握することは困難であった。また歩行者などの急な飛び出しに対して敏速に対応で

きないという問題もあった。一方、ビデオカメラ4に超広角レンズを取付けた場合には、視野は十分に広くとれて状況把握はできるが、距離感が把握できない欠点があった。

〔考案の目的〕

本考案は上述した点に鑑みてなされたものであり、簡単な構成で車両後方の状況を運転席で正しい距離感を持って容易に把握できる車両用後方監視装置を提供することを目的とする。

〔考案の概要〕

本考案は車両の後部に載置されたビデオカメラによって撮像された車両後方の映像を、車両の運転席近傍に載置されたモニタテレビに映し出すときに、前記ビデオカメラの前面に部分的に板厚を変えた透明板を設けて、必要部分を広角撮像できるようにして、所期の目的を達成するようにしたものである。

〔考案の実施例〕

以下、本考案に係る車両用後方監視装置の一実施例を図面を参照して説明する。

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第1図乃至第4図に本考案の一実施例を示す。これらの図において、第8図に示す従来例と同一または同等部分には同一符号を付して示す。乗用車1のトランクルーム1c内の後方にはビデオカメラ4が取り付けられており、トランクルーム1cの後方壁面1dにはこのビデオカメラ4の光軸と整合する位置に貫通孔1eが形成されていてビデオカメラ4の図示せぬレンズはこの貫通孔1eの方向に向けられている。このビデオカメラ4が撮像した画像信号の出力は被写体の左右を反転させる画像信号処理回路6に入力され、その出力は運転席1bに設けられたモニタテレビ5に入力されるように構成されている。被写体の画像信号の出力を左右反転させることは、運転者が向いている方向とビデオカメラ4が向いている方向が逆であるため必要である。また前記トランクルーム1cの後方下部には外側に向って照明するライト7が設けられており、夜間のバック走行時にライトキー入力とバックギヤ入力が同時に入るときに、このライト7が必要な照度で点灯されるようになっ

14-A

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ている。

前記ビデオカメラ4は第2図及び第3図に示すように前記トランクルーム1cの後方壁面1dに取付けられている。すなわち、ビデオカメラ4は段付円板状のシャーシ8によって支持されており、このシャーシ8はトランクルーム1cの後方壁面1d及びシャーシ8の外周近くにそれぞれ形成された少くとも3個の取付孔1f、及び8aを介して図示せぬボルトによりトランクルーム1cに内側から取付けられている。そして前述した貫通孔1eがこのシャーシ8に対向する位置の後方壁面に形成されており、前記ビデオカメラ4に外部の映像を入射できるようになっている。この貫通孔1eにはゴム製シール部材9を介して板ガラス10が保持されている。従って、ビデオカメラ4の前面に設けられた図示せぬレンズの表面は板ガラス10とシャーシ8との間にほぼ密閉されており、塵埃が付着することはほとんどない。この板ガラス10とシャーシ8との間の空間は、熱膨張の影響を避けるためにシャーシ8に形成された小孔8b

が開口しているだけである。この板ガラス１０は部分的に厚みが変えられている。この板ガラス10の厚みの変化は、ビデオカメラ４が撮像したテレビ画像のうち、第４図に示すモニタテレビ５の画面の下部の斜線で示す約1/3の領域１１が超広角画面となるように、第２図で示す板ガラス１０の角度範囲１０ａで板厚が下方に向って次第に厚くなるように形成されている。モニタテレビ５の残りの上部約2/3の領域１２は、通常のレンズを通った画面となるように板ガラス１０の角度範囲１０ｂでは板厚が均一になっている。

14-B

上述した本実施例の作用を以下に説明する。ビデオカメラ４の前面に設けられた板ガラス１０の角度範囲１０ａで板厚が下方に向って次第に厚くなっているため、乗用車１の後方広角撮像が可能となり、例えば後部バンパー１３などの車体の一部を撮像することができる。従って、モニタテレビ５の画面の下部領域１１には乗用車１の後方が圧縮されて広範囲に映し出され、乗用車１の一部も映し出されるので、注意する対象物までのおお

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よその距離を知ることができる。また板ガラス10の角度範囲１０ｂでは板厚が均一となっているため通常のビデオカメラ４のレンズによる撮像となり、モニタテレビ５の画面の上部領域１２には通常使われるバックミラーによる映像と同様の映像が映し出される。

本実施例によれば、乗用車１の後方を映し出すモニタテレビの画面の上方の大部分において、通常使われるバックミラーの距離感を持った映像が見られ、下方の一部分において安全確認に必要な周囲状況が圧縮された映像として見られるので、自動車１の後方の状況把握が容易になる。

第５図は本考案の他の実施例を示し、板ガラス１０の厚みの変化を下部の１０ａの角度範囲のみならず左右方向にも設けて、モニタテレビ５の画面上で下部１１及び両側１３において圧縮された広角映像が見られるようにしたものである。

また第６図に示すように夜間照明用のライト９はシャーシ８と板ガラス１０との間に設けてもよい。さらにまた板ガラス１０に相当する厚みの変

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化のある透明部材をビデオカメラ4のレンズ構成の中の1枚としてもよい。

上述した実施例ではビデオカメラ4の前部に板ガラス10を設けた場合について説明したが、この板ガラス10は透明なプラスチック部材を必要な板厚変化が形成されるように型で成型されたものであってもよい。また上述した実施例では乗用車の後方監視装置について説明したが、乗用車以外の車両に設置しても同様の効果がある。

〔考案の効果〕

上述したように本考案によれば、簡単な構成で車両後方の状況を運転席で正しい距離感を持って容易に把握することができる。

4. 図面の簡単な説明

第1図は本考案に係る車両用後方監視装置の一実施例を車両に装着した状態を示すシステム図、第2図は第1図のビデオカメラ部を示す縦断面図、第3図は第2図の斜視図、第4図は第1図のモニタテレビ画面を示す正面図、第5図及び第6図は本考案の他の実施例を示すそれぞれ正面図及び縦

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断面図、第７図及び第８図は従来の車両用後方監視装置を示すシステム図である。

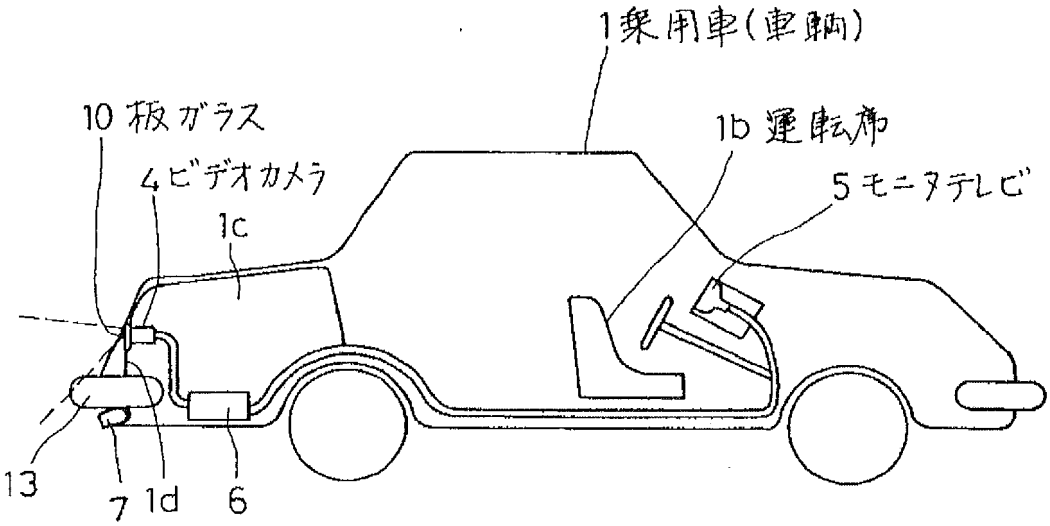
１…乗用車（車両）　１ｂ…運転席

４…ビデオカメラ　５…モニタテレビ

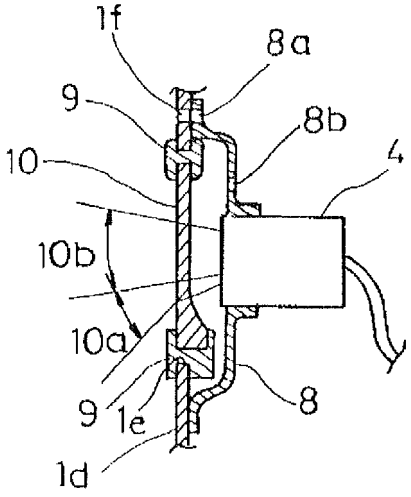
１０…板ガラス（透明板）。

代理人　弁理士　則　近　憲　佑

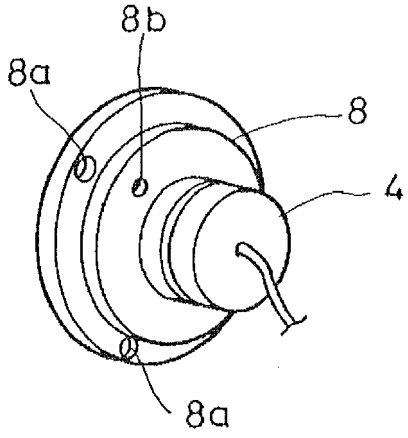
同　　宇　治　　弘



第 1 図



第 2 図



第 3 図

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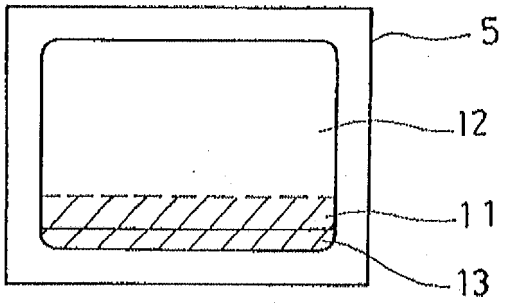
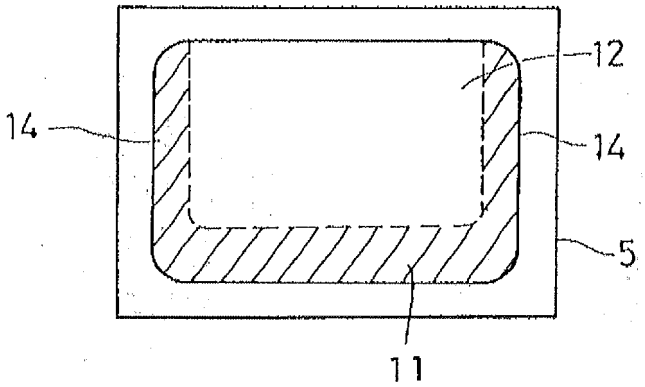
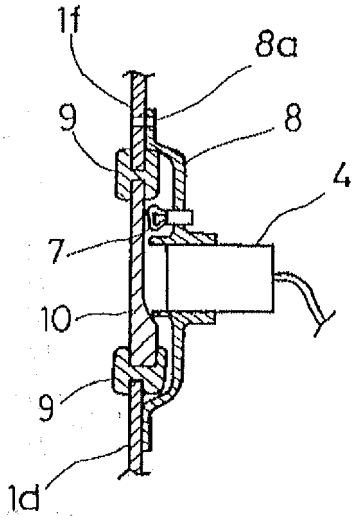
実開 72245



第 4 図



第 5 図



第 6 図

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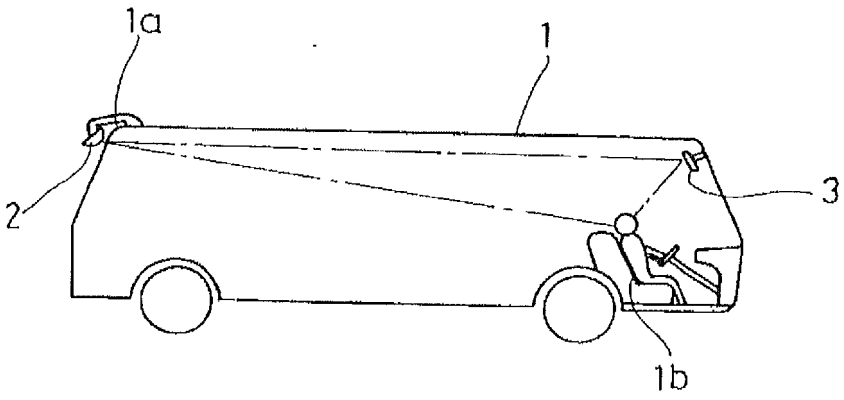
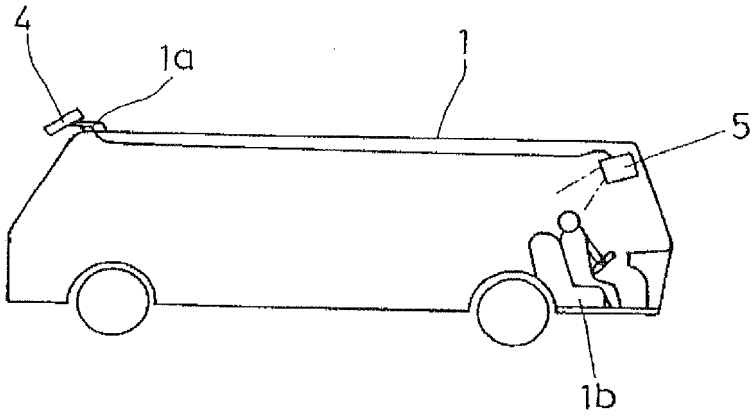


第 7 図



第 8 図

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Translation of

Japanese Laid-Open Utility Model Application No. 62-72245

Publication Date: May 8,1987

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1. TITLE OF INVENTION

A Rear Monitor On A Vehicle

2. Claim Of Utility Model Registration

A rear monitor on a vehicle comprising:

a video camera mounted on rear of said vehicle for capturing rear image of said vehicle;

a monitor television mounted near the driver's seat and for displaying the image captured by said video camera; and

a transparent plate provided in front of said video camera and for enabling a wide-angle image capture by partially changed thickness thereof.

3. Detailed Explanation Of The Invention

[Field Of The Invention]

The present invention relates to a rear monitor on a vehicle and particularly relates to rear monitor using a video camera and a monitor television on the vehicle.

[Background Of The Invention]

Conventionally, in case field of view for rear of a vehicle is significantly restricted at the driver's seat such as a large truck and a bus, a manner shown in FIG. 7 or FIG. 8 was taken for safety confirmation. As shown in FIG. 7, a large convex mirror 2 was mounted on a rear upper part 1a of the vehicle 1 to reflect a wide range of the field of view in the rear of the vehicle and the reflected field of view was projected to a rearview mirror 3 that was mounted near the driver's seat 1b. Alternatively, as shown in FIG. 8, a video camera 4 was installed in a rear upper part 1a of vehicle 1 to capture very close range of the field of view in the rear of the vehicle and the captured video signal was displayed to a monitor television 5 that was mounted near the driver's seat 1b.

[Drawbacks Of The Background Art]

However, as shown in FIG. 7, when a rear image of the vehicle was projected to the rearview mirror 3 from the large convex mirror 2, an object looked small due to factors such as a long distance from the driver's seat 1b to the object and identification was difficult enough. Further, as shown in FIG. 8, a video camera 4 was beneficial because a place to be watched could be zoomed in for confirmation, but a view angle was so small to satisfactorily grasp conditions around the vehicle if a standard lens was only employed. In addition, there was a problem not to be able to immediately respond to the sudden appearance such as pedestrians. Instead, when a superwide-angle lens was attached to the video camera 4, the field of view could be wide enough to grasp conditions around the vehicle but there was a drawback that a sense of distance could not be obtained.

[Object Of The Invention]

An object of the present invention is to solve the above conventional drawback. Another object of the present invention is to provide a rear monitor on a vehicle that can grasp conditions in rear of the vehicle at the driver's seat together with the sense of correct distance by a simple configuration.

[Summary Of The Invention]

The present invention achieves an anticipated purpose by a wide-angle image capture for a needed field of view through a transparent plate which has a partial change in thickness and is arranged in front of said video camera, when a video camera captures a rear image of the vehicle and the captured image is displayed in a monitor television mounted near the driver's seat.

[Preferred Embodiments]

Referring to accompanied drawings, an embodiment of a rear monitor on a vehicle of the present invention is explained.

An embodiment of the present invention is shown in FIGs. 1-4. In these drawings, identical symbols are used for equivalents of the conventional elements shown in FIG. 8. A video camera 4 is attached to a rear in a trunk room 1c of a passenger car 1. A through-hole 1e is formed at the position matching an optical axis of the video camera 4 in a rear wall 1d of the trunk room 1c. A lens (not shown) of the video camera 4 is directed to the through-hole 1e. An output video signal captured by the video camera 4 is supplied to an image processing circuit 6 that reverses right and left of the captured object. The output from the image processing circuit 6 is supplied to a monitor television 5 that is mounted near driver seat 1b. It is necessary for the captured video signal to be reversed in right and left because the driver

14-A

faces an opposite direction to the field of view of the video camera 4. Further, an illumination 7 is mounted at a rear lower part of the trunk room 1c to lighten the outside, and lights up with a satisfactory brightness when an illumination key entry and a reverse gear entry are simultaneously supplied under rearward travel at night.

The video camera 4 is attached to rear wall 1d of the trunk room 1c as shown in FIG. 2 and FIG. 3. The video camera 4 is supported by a chassis 8 of a stepped dish form, and the chassis 8 is attached inside the trunk room 1c by screws (not shown) through at least three pairs of mounting holes 1f and 8a that are formed on the rear wall 1d of the trunk room 1c and an outer circumferential part of the chassis 8 respectively. The above described through-hole 1e is formed at a position that faces the chassis 8 in the rear wall and an external image can be captured by the video camera 4 through the through-hole 1e. In this through-hole 1e, a rubber seal member 9 retains a flat glass 10. Accordingly, surface of the lens (not shown) that is mounted in front of the video camera 4 is almost sealed between the flat glass 10 and the chassis 8 so that dust is rarely stacked to the lens (not shown). In a space between the flat glass 10 and the chassis 8, only a small hole 8b is opened through the chassis 8 to avoid influence of the thermal expansion. Thickness of the flat glass 10 is changed partially. As shown in FIG. 2, the change in thickness of the plate glass 10 becomes gradually thicker toward the lower part in an angular range 10a of the plate glass 10 so that a domain 11 becomes a super wide-angle screen, wherein the domain 11 represents approximately one-third of the lower part in the screen of the monitor television 5 among the video image captured by the video camera 4, as shown in FIG. 4 with the slanted lined domain. A remaining upper domain 12 is about two-thirds of monitor television 5, and an angular range 10b of the flat glass 10 has uniform thickness in the domain 12 so that the domain 12 provides an image through the normal lens. 14-B

Hereinafter, operation of this embodiment is explained below. Due to the gradually increased thickness toward the lower part in the angular range 10a of the flat glass 10 provided in front of the video camera 4, the video camera 4 can capture the wide-angle rear image of the car and a part of the vehicle body such as a rear bumper 13 can be captured. Therefore, field of view at the rear of the car 1 is compressed and widely displayed in the lower domain 11 of the screen of the monitor television 5 together with a part of the car 1, and an approximate distance to an object of attention can be grasped. Further, due to the uniform thickness in the angular range 10b of the flat glass 10, the video camera 4 captures an image through the normal lens and an equivalent image to the rearview mirror is displayed in upper domain 12 of the screen of the monitor television 5.

According to the present embodiment, the image with the sense of distance similar to the rearview mirror can be displayed in most of the upper part of the screen of the monitor television that displays rear of the car 1, and an ambient condition necessary for safety confirmation can be displayed in the lower part as the compressed image. Therefore, a condition in rear of the car 1 can be grasped easily.

FIG. 5 shows another embodiment of the present invention, wherein the change in thickness of the flat glass 10 is provided not only the angular range of 10a of the lower part but also right and left portions so that a wide-angle compressed image can be displayed at a lower portion 11 and both sides 13 on the screen of the monitor television 5.

Further, as shown in FIG. 6, an illumination 9 for nightlight may be provided between the chassis 8 and the flat glass 10. Furthermore, a transparent member with the change in thickness that corresponds to the flat glass 10 may be one lens of the lens groups of the video camera 4.

In the above explained embodiments, although the flat glass 10 was provided in front of the video camera 4, the flat glass 10 may be a molded transparent plastic member with necessary change in thickness. Further, in the above embodiments, although a rear monitor on the passenger car was explained, the present invention may be installed on vehicle other than the passenger car, together with similar effects.

[Effect Of The Invention]

As described above, according to the present invention, condition in rear of the car can be easily grasped in the driver's seat together with the correct sense of distance by simple constitution.

4. Brief Description Of Drawings

FIG. 1 is a system chart of the present invention showing an embodiment of a rear monitor installed in a vehicle. FIG. 2 is a longitudinal cross sectional view of a video camera part of FIG. 1. FIG. 3 is a perspective view of FIG. 2. FIG. 4 is a front view of a screen of a monitor television of FIG. 1. FIG. 5 and FIG. 6 are a front view and a longitudinal cross sectional view of another embodiment of the present invention. FIG. 7 and FIG. 8 are system charts of the conventional rear monitors.

1 --- a car (a vehicle), 1b --- the driver's seat

4 --- a video camera, 5 --- a monitor television

10 --- a flat glass (a transparent plate).

Electronic Acknowledgement Receipt

EFS ID:	16577807
Application Number:	13800691
International Application Number:	
Confirmation Number:	4472
Title of Invention:	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE
First Named Inventor/Applicant Name:	Kenneth Schofield
Customer Number:	15671
Filer:	Timothy A. Flory/Amanda Sytsma
Filer Authorized By:	Timothy A. Flory
Attorney Docket Number:	MAG04 P-2059
Receipt Date:	13-AUG-2013
Filing Date:	13-MAR-2013
Time Stamp:	16:17:33
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	TransmittalForm.pdf	118734 e5ee7283f4b52242872edb65288f63e1c1c36611	no	1
Warnings:					
Information:					

2	Transmittal Letter	IDSLetter.pdf	14007 e53aaac12d179b4e8eb02ad705b74f33891c3cd3	no	1
Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Form (SB08)	IDSForms.pdf	244616 11b4f36b6fd628d74b21a3fd532e6b44c3ad554a	no	17
Warnings:					
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4	Foreign Reference	JP0550883.pdf	559395 d0634bc68a8bdae02aeca04e6b933879f05c64ae	no	9
Warnings:					
Information:					
5	Foreign Reference	JP2003083742.pdf	553186 ecfee0dc657cb5b3a3cf1d8c135267ed1e613f4c	no	12
Warnings:					
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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

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Doc Code: TRAN.LET

Document Description: Transmittal Letter

PTO/SB/21 (07-09)
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TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Total Number of Pages in This Submission

Application Number	13/800,691
Filing Date	March 13, 2013
First Named Inventor	Kenneth Schofield
Art Unit	2486
Examiner Name	Anand Shashikant Rao
Attorney Docket Number	MAG04 P-2059

ENCLOSURES (*Check all that apply*)

- ☐ Fee Transmittal Form
  - ☐ Fee Attached
- ☐ Amendment/Reply
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
- ☐ Extension of Time Request
- ☐ Express Abandonment Request
- ☑ Information Disclosure Statement
- ☐ Certified Copy of Priority Document(s)
- ☐ Reply to Missing Parts/ Incomplete Application
  - ☐ Reply to Missing Parts under 37 CFR 1.52 or 1.53
- ☐ Drawing(s)
- ☐ Licensing-related Papers
- ☐ Petition
- ☐ Petition to Convert to a Provisional Application
- ☐ Power of Attorney, Revocation Change of Correspondence Address
- ☐ Terminal Disclaimer
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- ☐ CD, Number of CD(s) _____
  - ☐ Landscape Table on CD
- ☐ After Allowance Communication to TC
- ☐ Appeal Communication to Board of Appeals and Interferences
- ☐ Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- ☐ Proprietary Information
- ☐ Status Letter
- ☐ Other Enclosure(s) (please Identify below):

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	GARDNER, LINN, BURKHART & FLORY, LLP		
Signature	/taf/		
Printed name	Timothy A . Flory		
Date	August 13, 2013	Reg. No.	42540

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Signature	/ars/		
Typed or printed name	Amanda R. Sytsma	Date	August 13, 2013

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group	:	2486
Examiner	:	Anand Shashikant Rao
Serial No.	:	13/800,691
Filing Date	:	March 13, 2013
Inventors	:	Kenneth Schofield, Mark L. Larson and Keith J. Vadas
For	:	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

INFORMATION DISCLOSURE STATEMENT

In accordance with 37 CFR 1.51, 1.56, 1.97 and 1.98, Applicants submit herewith patents, publications or other information listed on the attached forms for consideration by the Examiner in connection with examination of the present application. Copies of some of the cited non-U.S. patent /publication references are not provided herewith, since these references were previously made of record during prosecution of the parent application Serial No. 12/688,146.

This Information Disclosure Statement is not intended to constitute an admission that any patent, publication or other information referred to herein is "prior art" for this invention unless specifically designated as such.

Under 37 CFR 1.97, the filing of this Information Disclosure Statement shall not be construed to mean that a search has been made or that no other material information as defined in 37 CFR 1.56(a) exists.

An early and favorable action on the merits is respectfully requested.

Respectfully submitted,

Date: August 13, 2013

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NOTICE OF ALLOWANCE AND FEE(S) DUE

15671 7590 12/11/2013

Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr., SE, Suite 207
Grand Rapids, MI 49546

EXAMINER
RAO, ANAND SHASHIKANT

ART UNIT	PAPER NUMBER
2486	

DATE MAILED: 12/11/2013

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/800,691	03/13/2013	Kenneth Schofield	MAG04 P-2059	4472

TITLE OF INVENTION: MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1780	$300	$0	$2080	03/11/2014

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

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III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

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15671 7590 12/11/2013
Gardner, Linn, Burkhart & Flory, LLP
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I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/800,691	03/13/2013	Kenneth Schofield	MAG04 P-2059	4472

TITLE OF INVENTION: MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1780	$300	$0	$2080	03/11/2014

EXAMINER	ART UNIT	CLASS-SUBCLASS
RAO, ANAND SHASHIKANT	2486	348-148000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
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3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
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- ❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29	NOTE: Absent a valid certification of Micro Entity Status (see form PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
❑ Applicant asserting small entity status. See 37 CFR 1.27	NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
❑ Applicant changing to regular undiscounted fee status.	NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

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This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/800,691	03/13/2013	Kenneth Schofield	MAG04 P-2059	4472

15671 7590 12/11/2013

Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr., SE, Suite 207
Grand Rapids, MI 49546

EXAMINER	
RAO, ANAND SHASHIKANT	
ART UNIT	PAPER NUMBER
2486	

DATE MAILED: 12/11/2013

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

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Notices of Allowance and Fee(s) Due mailed between October 1, 2013 and December 31, 2013

(Addendum to PTOL-85)

If the "Notice of Allowance and Fee(s) Due" has a mailing date on or after October 1, 2013 and before January 1, 2014, the following information is applicable to this application.

If the issue fee is being timely paid on or after January 1, 2014, the amount due is the issue fee and publication fee in effect January 1, 2014. On January 1, 2014, the issue fees set forth in 37 CFR 1.18 decrease significantly and the publication fee set forth in 37 CFR 1.18(d)(1) decreases to $0.

If an issue fee or publication fee has been previously paid in this application, applicant is not entitled to a refund of the difference between the amount paid and the amount in effect on January 1, 2014.

Notice of Allowability	Application No. 13/800,691	Applicant(s) SCHOFIELD ET AL.	
	Examiner ANDY RAO	Art Unit 2486	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the IDS of 8/13/13*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-86*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 8/13/13
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/ANDY RAO/
Primary Examiner, Art Unit 2486

Allowable Subject Matter

1. The present application is being examined under the pre-AIA first to invent provisions.

2. Claims 1-86 are allowed.

Independent claims 1, 49, 65, and 78 are directed towards a multi-vision system for a vehicle, said vehicular multi-camera vision system and further recites "…wherein second image data captured by said second image capture device is received at said image processor via at least one of an analog data stream and a digital data stream; wherein third image data captured by said third image capture device is received at said image processor via at least one of an analog data stream and a digital data stream; wherein, responsive to processing by said image processor of received image data, a synthesized image is generated without duplication of objects present in said first overlap zone and in said second overlap zone and wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle; and wherein said synthesized image is displayed by a single display screen of a reconfigurable display device that is viewable by a driver of the equipped vehicle when normally operating the equipped vehicle…" which are features that are not anticipated nor obvious over the art of record. Dependent claims 2-48, 50-64, 66-77, and 79-86 are allowed for the reasons concerning the independent claims.

Conclusion

3. Any inquiry concerning this communication or earlier communications from the examiner should be directed to ANDY RAO whose telephone number is (571)272-7337. The examiner can normally be reached on Monday-Friday 9AM-5:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mehrdad Dastouri can be reached on 571-272-7418. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

asr
/ANDY RAO/
Primary Examiner, Art Unit 2486
December 6, 2013

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13800691	SCHOFIELD ET AL.
	Examiner	**Art Unit**
	ANDY RAO	2486

CPC		
Symbol	**Type**	**Version**

CPC Combination Sets				
Symbol	**Type**	**Set**	**Ranking**	**Version**

NONE (Assistant Examiner) (Date)	**Total Claims Allowed:** 86	
/ANDY RAO/ Primary Examiner.Art Unit 2486 (Primary Examiner) (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

U.S. Patent and Trademark Office Part of Paper No. 20131206

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13800691	SCHOFIELD ET AL.
	Examiner	**Art Unit**
	ANDY RAO	2486

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION										
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED					
348	148	H	0	4	N	7 / 18 (2006.01.01)						

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
348	113	115			

NONE	Total Claims Allowed:	
(Assistant Examiner) (Date)	86	
/ANDY RAO/ Primary Examiner.Art Unit 2486	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner) (Date)	1	1

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13800691	SCHOFIELD ET AL.
	Examiner	**Art Unit**
	ANDY RAO	2486

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	17	17	33	33	49	49	65	65	81	81				
2	2	18	18	34	34	50	50	66	66	82	82				
3	3	19	19	35	35	51	51	67	67	83	83				
4	4	20	20	36	36	52	52	68	68	84	84				
5	5	21	21	37	37	53	53	69	69	85	85				
6	6	22	22	38	38	54	54	70	70	86	86				
7	7	23	23	39	39	55	55	71	71						
8	8	224	24	40	40	56	56	72	72						
9	9	25	25	41	41	57	57	73	73						
10	10	26	26	42	42	58	58	74	74						
11	11	27	27	43	43	59	59	75	75						
12	12	28	28	44	44	60	60	76	76						
13	13	29	29	45	45	61	74	77	77						
14	14	30	30	46	46	62	62	78	78						
15	15	31	31	47	47	63	63	79	79						
16	16	32	32	48	48	64	64	80	80						

NONE (Assistant Examiner) (Date)	**Total Claims Allowed:** 86
/ANDY RAO/ Primary Examiner.Art Unit 2486 (Primary Examiner) (Date)	O.G. Print Claim(s): 1 O.G. Print Figure: 1

U.S. Patent and Trademark Office Part of Paper No. 20131206

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Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

				Complete if Known	
				Application Number	13/800,691
				Filing Date	March 13, 2013
				First Named Inventor	Kenneth Schofield
				Art Unit	2486
				Examiner Name	Anand Shashikant Rao
Sheet	1	of	17	Attorney Docket Number	MAG04 P-2059

U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		8,224,031	07-17-2012	Saito	
		8,098,142	01-17-2012	Schofield et al.	
		8,095,310	01-10-2012	Taylor et al.	
		8,017,898	09-13-2011	Lu et al.	
		7,930,160	04-19-2011	Hosagrahara et al.	
		7,914,187	03-29-2011	Higgins-Luthman et al.	
		7,881,496	02-01-2011	Camilleri	
		7,859,565	12-28-2010	Schofield et al.	
		7,855,778	12-21-2010	Yung et al.	
		7,843,451	11-30-2010	Lafon	
		7,792,329	09-07-2010	Schofield et al.	
		7,720,580	05-18-2010	Higgins-Luthman	
		7,676,087	03-09-2010	Dhua et al.	
		7,639,149	12-29-2009	Katoh	
		7,633,383	12-15-2009	Dunsmoir et al.	
		7,619,508	11-17-2009	Lynam et al.	
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		7,561,181	07-14-2009	Schofield et al.	
		7,541,743	06-02-2009	Salmeen et al.	
		7,526,103	04-28-2009	Schofield et al.	
		7,459,664	12-02-2008	Schofield et al.	
		7,425,076	09-16-2008	Schofield et al.	
		7,423,248	09-09-2008	Schofield et al	
		7,423,821	09-09-2008	Bechtel et al.	
		7,402,786	07-22-2008	Schofield et al.	
		7,388,182	06-17-2008	Schofield et al.	
		7,380,948	06-03-2008	Schofield et al.	
		7,375,803	05-20-2008	Bamji	
		7,370,983	05-13-2008	DeWind et al.	
		7,360,932	04-22-2008	Uken et al.	
		7,344,261	03-18-2008	Schofield et al.	
		7,339,149	03-04-2008	Schofield et al.	

Examiner Signature	/Anand Rao/ (12/06/2013)	Date Considered	12/06/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation it not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R./

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Application Number	13/800,691
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First Named Inventor	Kenneth Schofield
Art Unit	2486
Examiner Name	Anand Shashikant Rao
Attorney Docket Number	MAG04 P-2059

Sheet 2 of 17

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		7,338,177	03-04-2008	Lynam	
		7,325,935	02-05-2008	Schofield et al.	
		7,325,934	02-05-2008	Schofield et al.	
		7,311,406	12-25-2007	Schofield et al.	
		7,255,451	08-14-2007	McCabe et al.	
		7,253,723	08-07-2007	Lindahl et al.	
		7,249,860	07-31-2007	Kulas et al.	
		7,227,611	06-05-2007	Hull et al.	
		7,227,459	06-05-2007	Bos et al.	
		7,224,324	05-29-2007	Quist et al.	
		7,202,776	04-10-2007	Breed	
		7,195,381	03-27-2007	Lynam et al.	
		7,167,796	01-23-2007	Taylor et al.	
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		7,123,168	10-17-2006	Schofield	
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		7,085,637	08-01-2006	Breed et al.	
		7,065,432	06-20-2006	Moisel et al.	
		7,062,300	06-13-2006	Kim	
		7,046,448	05-16-2006	Burgner	
		7,038,577	05-02-2006	Pawlicki et al.	
		7,005,974	02-28-2006	McMahon et al.	
		7,004,606	02-28-2006	Schofield	
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		6,975,775	12-13-2005	Rykowski et al.	
		6,968,736	11-29-2005	Lynam	
		6,953,253	10-11-2005	Schofield et al.	
		6,946,978	09-20-2005	Schofield	
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		6,891,563	05-10-2005	Schofield et al.	
		6,889,161	05-03-2005	Winner et al.	

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		6,882,287	04-19-2005	Schofield	
		6,847,487	01-25-2005	Burgner	
		6,831,261	12-14-2004	Schofield et al.	
		6,824,281	11-30-2004	Schofield et al.	
		6,823,241	11-23-2004	Shirato et al.	
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		6,806,452	10-19-2004	Bos et al.	
		6,802,617	10-12-2004	Schofield et al.	
		6,795,221	09-21-2004	Urey	
		6,794,119	09-21-2004	Miles	
		6,762,867	07-13-2004	Lippert et al.	
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		6,710,908	03-23-2004	Miles et al.	
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		6,700,605	03-02-2004	Toyoda et al.	
		6,690,268	02-10-2004	Schofield et al.	
		6,680,792	01-20-2004	Miles	
		6,678,614	01-13-2004	McCarthy et al.	
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		6,674,562	01-06-2004	Miles	
		6,672,731	01-06-2004	Schnell et al.	
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		6,650,233	11-18-2003	DeLine et al.	
		6,648,477	11-08-2003	Hutzel et al.	
		6,636,258	10-212003	Strumolo	
		6,631,994	10-14-2003	Suzuki et al.	

Examiner Signature	/Anand Rao/ (12/06/2013)	Date Considered	12/06/2013

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This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: **Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450**.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R./

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Art Unit	2486
Examiner Name	Anand Shashikant Rao
Attorney Docket Number	MAG04 P-2059

Sheet 4 of 17

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		6,627,918	09-30-2003	Getz et al.	
		6,611,610	08-26-2003	Stam et al.	
		6,611,202	08-26-2003	Schofield et al.	
		6,594,583	07-15-2003	Ogura et al.	
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		6,589,625	07-08-2003	Kothari et al.	
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		6,539,306	03-25-2003	Turnbull	
		6,534,884	03-18-2003	Marcus et al.	
		6,523,964	02-25-2003	Schofield et al.	
		6,516,664	02-11-2003	Lynam	
		6,513,252	02-04-2003	Schierbeek et al.	
		6,498,620	12-24-2002	Schofield et al.	
		6,497,503	12-24-2002	Dassanayake et al.	
		6,485,155	11-26-2002	Duroux et al.	
		6,477,464	11-05-2002	McCarthy et al.	
		6,442,465	08-27-2002	Breed et al.	
		6,433,817	08-13-2002	Guerra	
		6,433,676	08-13-2002	DeLine et al.	
		6,430,303	08-06-2002	Naoi et al.	
		6,428,172	08-06-2002	Hutzel et al.	
		6,424,273	07-23-2002	Gutta et al.	
		6,420,975	07-16-2002	DeLine et al.	
		6,411,328	06-25-2002	Franke et al.	
		6,411,204	06-25-2002	Bloomfield et al.	
		6,396,397	05-28-2002	Bos et al.	
		6,370,329	04-09-2002	Teuchert	
		6,366,213	04-02-2002	DeLine et al.	

Examiner Signature	/Anand Rao/ (12/06/2013)	Date Considered	12/06/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation it not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

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U. S. PATENT DOCUMENTS					
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		6,353,392	03-05-2002	Schofield et al.	
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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Complete if Known	
Application Number	13/800,691
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First Named Inventor	Kenneth Schofield
Art Unit	2486
Examiner Name	Anand Shashikant Rao
Attorney Docket Number	MAG04 P-2059

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U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
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U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		4,838,650	06-13-1989	Stewart	
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Examiner Signature	/Anand Rao/ (12/06/2013)	Date Considered	12/06/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation it not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R./

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known	
Application Number	13/800,691
Filing Date	March 13, 2013
First Named Inventor	Kenneth Schofield
Art Unit	2486
Examiner Name	Anand Shashikant Rao
Attorney Docket Number	MAG04 P-2059

Sheet 13 of 17

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		4,600,913	07-15-1986	Caine	
		4,580,875	04-08-1986	Bechtel	
		4,572,619	02-25-1986	Reininger	
		4,571,082	02-18-1986	Downs	
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Examiner Signature	/Anand Rao/ (12/06/2013)	Date Considered	12/06/2013

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Approved for use through 07/31/2006. OMB 0651-0031
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				Complete if Known	
				Application Number	13/800,691
				Filing Date	March 13, 2013
				First Named Inventor	Kenneth Schofield
				Art Unit	2486
				Examiner Name	Anand Shashikant Rao
Sheet	14	of	17	Attorney Docket Number	MAG04 P-2059

U. S. PATENT DOCUMENTS					
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		2009/0190015	07-30-2009	Bechtel et al.	
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		DE3248511	07-05-1984	Bissenden		X
		DE4107965	09-26-1991	Loidl		X
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		JP6080953	05-08-1985	Niles Parts Co. Ltd.		X
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				Art Unit	2486
				Examiner Name	Anand Shashikant Rao
Sheet	17	of	17	Attorney Docket Number	MAG04 P-2059

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
		G. WANG, D. RENSHAW, P.B. DENYER AND M. LU, CMOS Video Cameras, article, 1991, 4 pages, University of Edinburgh, UK.	
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Examiner Signature	/Anand Rao/ (12/06/2013)	Date Considered	12/06/2013

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BIB DATA SHEET

CONFIRMATION NO. 4472

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/800,691	03/13/2013 RULE	348	2486	MAG04 P-2059

APPLICANTS

DONNELLY CORPORATION, Holland, MI

INVENTORS

Kenneth Schofield, Holland, MI;
Mark L. Larson, Grand Haven, MI;
Keith J. Vadas, Coopersville, MI;

**** CONTINUING DATA ***************************

This application is a CON of 12/688,146 01/15/2010
which is a CON of 12/496,357 07/01/2009 PAT 8462204
which is a CON of 11/122,880 05/05/2005 PAT 7561181
which is a CON of 10/324,679 12/20/2002 PAT 6891563
which is a CON of 08/952,026 11/19/1997 PAT 6498620
which is a 371 of PCT/US1996/007382 05/22/1996

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

04/15/2013

Foreign Priority claimed	☐ Yes ☑ No	☐ Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
35 USC 119(a-d) conditions met	☐ Yes ☑ No		MI	13	86	4
Verified and Acknowledged	/ANDY SHASHIKANT RAO/ Examiner's Signature	AR Initials				

ADDRESS

Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr., SE, Suite 207
Grand Rapids, MI 49546
UNITED STATES

TITLE

MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

FILING FEE RECEIVED		
5602	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

BIB (Rev. 05/07).

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13800691	SCHOFIELD ET AL.
	Examiner	Art Unit
	ANDY RAO	2486

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/06/2013								
1	1	=								
2	2	=								
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13800691	SCHOFIELD ET AL.
	Examiner	Art Unit
	ANDY RAO	2486

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
348	111-115, 148	12/6/2013	AR

SEARCH NOTES		
Search Notes	Date	Examiner
Consulted Search Notes On Applications: #12/688,146, #12/496,357, #11/122,880, #10/324,679, and #08/952,026.	12/6/2013	AR

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
348	100-200	12/6/2013	AR

	/ANDY RAO/ Primary Examiner.Art Unit 2486

PATENT
MAG04 P-2059

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group Art : 2486
Examiner : Anand S. Rao
Inventors : Kenneth Schofield, Mark L. Larson and Keith J. Vadas
Serial No. : 13/800,691
Filing Date : March 13, 2013
For : MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

Confirmation No.: 4472
Notice of Allowance Mailing Date: December 11, 2013

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

AMENDMENT AFTER ALLOWANCE UNDER 37 CFR 1.312

Receipt of the Notice of Allowability and the Notice of Allowance and Fee(s) Due and Examiner's Amendment mailed December 11, 2013 in connection with the above identified application is hereby acknowledged.

Amendments to the Specification are on page 2 of this paper.

Amendments to the Claims are reflected in the listing of claims that begins on page 3 of this paper.

Remarks are on page 30 of this paper.

Amendments to the Specification:

Please amend paragraph [0001] on page 1 as follows:

[0001] This application is a continuation of U.S. patent application Ser. No. 12/688,146, filed Jan. 15, 2010 ~~(Attorney Docket MAG04 P-1585)~~, which is a continuation of U.S. patent application Ser. No. 12/496,357, filed Jul. 1, 2009, now U.S. Pat. No. 8,462,204 ~~(Attorney Docket MAG04 P-1536)~~, which is a continuation of U.S. patent application Ser. No. 11/122,880, filed May 5, 2005, now U.S. Pat. No. 7,561,181, which is a continuation of U.S. patent application Ser. No. 10/324,679, filed on Dec. 20, 2002, now U.S. Pat. No. 6,891,563, which is a continuation of U.S. patent application Ser. No. 08/952,026, filed under 35 U.S.C. § 371, filed Nov. 19, 1997, now U.S. Pat. No. 6,498,620, which is based on International Patent Application No. PCT/US96/07382, filed May 22, 1996.

Amendments to the Claims:

This listing of claims will replace all prior versions and listings of claims in the present application:

1 (currently amended): A multi-camera vision system for a vehicle, said vehicular multi-camera vision system comprising:

at least three image capture devices disposed at a vehicle equipped with said vehicular multi-camera vision system;

said at least three image capture devices comprising a first image capture device disposed at a driver-side portion of the equipped vehicle at a first location;

said at least three image capture devices comprising a second image capture device disposed at a passenger-side portion of the equipped vehicle at a second location;

said at least three image capture devices comprising a third image capture device disposed at a rear portion of the equipped vehicle at a third location;

wherein said first image capture device has a first field of view exterior of the equipped vehicle;

wherein said second image capture device has a second field of view exterior of the equipped vehicle;

wherein said third image capture device has a third field of view exterior of the equipped vehicle;

wherein said first field of view of said first image capture device overlaps with said third field of view of said third image capture device defining a first overlap zone;

wherein said second field of view of said second image capture device overlaps with said third field of view of said third image capture device defining a second overlap zone;

wherein said first image capture device captures first image data;

wherein said second image capture device captures second image data;

wherein said third image capture device captures third image data;

an image processor;

wherein first image data captured by said first image capture device is received at said image processor via at least one of an analog data stream and a digital data stream;

wherein second image data captured by said second image capture device is received at said image processor via at least one of an analog data stream and a digital data stream;

wherein third image data captured by said third image capture device is received at said image processor via at least one of an analog data stream and a digital data stream;

wherein, responsive to processing by said image processor of received image data, a synthesized image is generated without duplication of objects present in said first overlap zone and in said second overlap zone and wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle; and

wherein said synthesized image is displayed by a single display screen of a reconfigurable display device that is viewable by a driver of the equipped vehicle when normally operating the equipped vehicle.

2 (original): The vehicular multi-camera vision system of claim 1, wherein said single location is forward of the equipped vehicle.

3 (original): The vehicular multi-camera vision system of claim 1, wherein first image data captured by said first image capture device is received at said image processor via a digital data stream and wherein second image data captured by said second image capture device is received at said image processor via a digital data stream and

wherein third image data captured by said third image capture device is received at said image processor via a digital data stream.

4 (original): The vehicular multi-camera vision system of claim 1, wherein image data transmission from said first, second and third image capture devices to said image processor is by electrically conductive leads over a vehicle communication bus.

5 (original): The vehicular multi-camera vision system of claim 4, wherein said vehicle communication bus comprises a serial bus.

6 (original): The vehicular multi-camera vision system of claim 4, wherein said vehicle communication bus comprises a parallel bus.

7 (original): The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen includes a visual indication of the location of the equipped vehicle in said view.

8 (original): The rearview multi-camera vision system of claim 7, wherein said visual indication approximates the footprint occupied by the equipped vehicle.

9 (original): The vehicular multi-camera vision system of claim 7, wherein said visual indication comprises an outline of an area substantially occupied by the equipped vehicle.

10 (original): The vehicular multi-camera vision system of claim 1, wherein said first image capture device is disposed at the equipped vehicle at substantially the same height relative to ground as is said second image capture device.

11 (original): The vehicular multi-camera vision system of claim 10, wherein said first location where said first image capture device is disposed at the driver-side of the equipped vehicle is a first distance forward of where the driver sits when operating the equipped vehicle and wherein said second location where said second image capture device is disposed at the passenger-side of the equipped vehicle is a second distance forward of where the driver sits when operating the equipped vehicle.

12 (original): The vehicular multi-camera vision system of claim 11, wherein said first distance is substantially the same as said second distance.

13 (original): The vehicular multi-camera vision system of claim 11, wherein said third image capture device is at a height relative to ground that is lower than the height relative to ground of said first and second image capture devices, and wherein said third location is a third distance rearward of where the driver sits when operating the equipped vehicle and wherein said third distance is larger than either of said first and second distances.

14 (original): The vehicular multi-camera vision system of claim 1, wherein said at least three image capture devices have the principal axis of their respective field of view aimed along non-parallel axes.

15 (original): The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen approximates a rearward-facing view from a single location exterior of the equipped vehicle.

16 (original): The vehicular multi-camera vision system of claim 15, wherein said single location is forward of the equipped vehicle.

17 (original): The vehicular multi-camera vision system of claim 1, wherein a fourth image capture device is disposed at a front portion of the equipped vehicle.

18 (original): The vehicular multi-camera vision system of claim 17, wherein said single location is rearward of the equipped vehicle.

19 (original): The vehicular multi-camera vision system of claim 1, wherein each of said at least three image capture devices comprises a CMOS imaging array.

20 (original): The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen comprises a graphic overlay.

21 (original): The vehicular multi-camera vision system of claim 20, wherein said graphic overlay comprises indicia of the anticipated path of travel of the equipped vehicle.

22 (original): The vehicular multi-camera vision system of claim 20, wherein said graphic overlay comprises indicia indicating distance to objects exterior the equipped vehicle.

23 (original): The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen comprises enhancements that assist visually distinguishing objects close to the equipped vehicle.

24 (original): The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen comprises indicia and wherein said indicia responds to at least one of the vehicle's steering system, the vehicle's differential system and a compass.

25 (original): The vehicular multi-camera vision system of claim 1, wherein at least one of color and flashing is used to draw the driver's attention to a potential hazard present in the image displayed by said display screen.

26 (original): The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen comprises a graphic overlay that includes indicia of the anticipated path of travel of the equipped vehicle and wherein said graphic overlay is disabled when the vehicle's gear actuator is not in reverse gear.

27 (original): The vehicular multi-camera vision system of claim 1, wherein the display luminance of said display screen of said reconfigurable display device is variable responsive to a sensing of an ambient light level.

28 (original): The vehicular multi-camera vision system of claim 1, wherein the display luminance of said display screen of said reconfigurable display device is variable responsive to at least one of (i) a vehicle headlight activation control, (ii) an ambient light sensor and (iii) an indication of ambient light level detected by at least one of said first, second and third image capture devices.

29 (original): The vehicular multi-camera vision system of claim 1, wherein said display screen of said reconfigurable display device is operable to display at least one of (i) pager information, (ii) a telephone number listing, (iii) global positioning system data, (iv) a map, (v) route guidance information, (vi) intelligent vehicle highway system information, (vii) a vehicle radio control setting, (viii) a vehicle environmental system setting, (ix) vehicle speed, (x) vehicle heading, (xi) turn signal indicators and (xii) a radio setting.

30 (original): The vehicular multi-camera vision system of claim 1, wherein content displayed by said display screen of said reconfigurable display device is user-selectable.

31 (original): The vehicular multi-camera vision system of claim 1, wherein content displayed by said display screen of said reconfigurable display device is user-selectable via at least one of a keypad and a trackball.

32 (original): The vehicular multi-camera vision system of claim 1, wherein content displayed by said display screen of said reconfigurable display device is user-selectable via an input device located at a steering column of the equipped vehicle or at a dashboard of the equipped vehicle.

33 (original): The vehicular multi-camera vision system of claim 1, wherein said reconfigurable display device comprises a flat-panel display device.

34 (original): The vehicular multi-camera vision system of claim 33, wherein said flat-panel display device comprises a back-lit liquid crystal display device.

35 (original): The vehicular multi-camera vision system of claim 33, wherein said flat-panel display device comprises a light-emitting diode display device.

36 (original): The vehicular multi-camera vision system of claim 33, wherein said flat-panel display device comprises a plasma display device.

37 (original): The vehicular multi-camera vision system of claim 33, wherein said flat-panel display device is mounted at a dashboard of the equipped vehicle.

38 (original): The vehicular multi-camera vision system of claim 33, wherein said flat-panel display device is mounted at a facia of the equipped vehicle.

39 (original): The vehicular multi-camera vision system of claim 33, wherein each of said at least three image capture devices comprises an array of photosensing pixels and wherein a mosaic spectral filter masks incident radiation in order to produce pixels which respond respectively to red, green and blue light.

40 (original): The vehicular multi-camera vision system of claim 33, wherein each of said at least three image capture devices comprises an array of photosensing pixels and comprises filtering to least one of (a) at least partially block near infrared radiation from pixels of said array and (b) at least partially block infrared radiation from pixels of said array.

41 (currently amended): The vehicular multi-camera vision system of claim 1, wherein at least one of (a) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle into a loading dock, (b) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle with a trailer attached thereto, (c) said vehicular multi-camera vision system provides accident monitoring, (d) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and (e) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and to deploy a smart headrest in such an event.

42 (original): The vehicular multi-camera vision system of claim 1, wherein said first field of view said first image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom.

43 (original): The vehicular multi-camera vision system of claim 1, wherein said second field of view said second image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom.

44 (original): The vehicular multi-camera vision system of claim 1, wherein said display device comprises a circular polarizer.

45 (original): The vehicular multi-camera vision system of claim 1, wherein the image displayed by said display screen comprises a focal length that is substantially the depth of the field of the driver viewing objects beyond said equipped vehicle.

46 (original): The vehicular multi-camera vision system of claim 1, wherein said synthesized image displayed by said display screen approximates a panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle.

47 (original): The vehicular multi-camera vision system of claim 1, wherein said synthesized image displayed by said display screen approximates a substantially seamless panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle.

48 (original): The vehicular multi-camera vision system of claim 1, wherein said synthesized image displayed by said display screen approximates a substantially seamless view as would be viewed from a single virtual camera located exterior the equipped vehicle.

49 (original): A multi-camera vision system for a vehicle, said vehicular multi-camera vision system comprising:

at least three image capture devices disposed at a vehicle equipped with said vehicular multi-camera vision system;

said at least three image capture devices comprising a first image capture device disposed at a driver-side portion of the equipped vehicle at a first location;

said at least three image capture devices comprising a second image capture device disposed at a passenger-side portion of the equipped vehicle at a second location;

said at least three image capture devices comprising a third image capture device disposed at a rear portion of the equipped vehicle at a third location;

wherein said first image capture device has a first field of view exterior of the equipped vehicle;

wherein said second image capture device has a second field of view exterior of the equipped vehicle;

wherein said third image capture device has a third field of view exterior of the equipped vehicle;

wherein said first field of view of said first image capture device overlaps with said third field of view of said third image capture device defining a first overlap zone;

wherein said second field of view of said second image capture device overlaps with said third field of view of said third image capture device defining a second overlap zone;

wherein said first image capture device captures first image data;

wherein said second image capture device captures second image data;

wherein said third image capture device captures second image data;

wherein each of said at least three image capture devices comprises a CMOS imaging array;

wherein said first image capture device is disposed at the equipped vehicle at substantially the same height relative to ground as is said second image capture device;

wherein said third vehicular camera disposed at the rear of the equipped vehicle is operable as a backup camera;

an image processor;

wherein first image data captured by said first image capture device is received at said image processor;

wherein second image data captured by said second image capture device is received at said image processor;

wherein third image data captured by said third image capture device is received at said image processor;

wherein, responsive to processing by said image processor of received image data, a synthesized image is generated without duplication of objects present in said first overlap zone and in said second overlap zone and wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle;

wherein said synthesized image is displayed by a single display screen of a reconfigurable display device that is viewable by a driver of the equipped vehicle when normally operating the equipped vehicle; and

wherein at least one of (a) said synthesized image displayed by said display screen approximates a panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle, (b) said synthesized image displayed by said display screen approximates a substantially seamless panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle and (c) said synthesized image displayed by said display screen approximates a substantially seamless view as would be viewed from a single virtual camera located exterior the equipped vehicle.

50 (original): The vehicular multi-camera vision system of claim 49, wherein first image data captured by said first image capture device is received at said image processor via

a digital data stream and wherein second image data captured by said second image capture device is received at said image processor via a digital data stream and wherein third image data captured by said third image capture device is received at said image processor via a digital data stream.

51 (original): The vehicular multi-camera vision system of claim 49, wherein image data transmission from said first, second and third image capture devices to said image processor is by electrically conductive leads over a vehicle communication bus.

52 (original): The vehicular multi-camera vision system of claim 49, wherein the image displayed by said display screen includes a visual indication of the location of the equipped vehicle in said view and wherein at least one of (a) said visual indication approximates the footprint occupied by the equipped vehicle and (b) wherein said visual indication comprises an outline of an area substantially occupied by the equipped vehicle.

53 (original): The vehicular multi-camera vision system of claim 49, wherein said first location where said first image capture device is disposed at the driver-side of the equipped vehicle is a first distance forward of where the driver sits when operating the equipped vehicle and wherein said second location where said second image capture device is disposed at the passenger-side of the equipped vehicle is a second distance forward of where the driver sits when operating the equipped vehicle, and wherein said first distance is substantially the same as said second distance, and wherein said third image capture device is at a height relative to ground that is lower than the height relative to ground of said first and second image capture devices, and wherein said third location is a third distance rearward of where the driver sits when operating the equipped vehicle and wherein said third distance is larger than either of said first and second distances.

54 (original): The vehicular multi-camera vision system of claim 49, wherein said at least three image capture devices have the principal axis of their respective field of view aimed along non-parallel axes.

55 (original): The vehicular multi-camera vision system of claim 49, wherein the image displayed by said display screen comprises a graphic overlay and wherein at least one of (i) said graphic overlay comprises indicia of the anticipated path of travel of the equipped vehicle and (ii) said graphic overlay comprises indicia indicating distance to objects exterior the equipped vehicle.

56 (original): The vehicular multi-camera vision system of claim 49, wherein at least one of (a) the image displayed by said display screen comprises enhancements that assist visually distinguishing objects close to the equipped vehicle, (b) the image displayed by said display screen comprises indicia and wherein said indicia responds to at least one of the vehicle's steering system, the vehicle's differential system and a compass, (c) at least one of color and flashing is used to draw the driver's attention to a potential hazard present in the image displayed by said display screen and (d) the image displayed by said display screen comprises a graphic overlay that includes indicia of the anticipated path of travel of the equipped vehicle and wherein said graphic overlay is disabled when the vehicle's gear actuator is not in reverse gear.

57 (original): The vehicular multi-camera vision system of claim 49, wherein at least one of (a) the display luminance of said display screen of said reconfigurable display device is variable responsive to a sensing of an ambient light level and (b) the display luminance of said display screen of said reconfigurable display device is variable responsive to at least one of (i) a vehicle headlight activation control, (ii) an ambient

light sensor and (iii) an indication of ambient light level detected by at least one of said first, second and third image capture devices.

58 (original): The vehicular multi-camera vision system of claim 49, wherein at least one of (a) said display screen of said reconfigurable display device is operable to display at least one of (i) pager information, (ii) a telephone number listing, (iii) global positioning system data, (iv) a map, (v) route guidance information, (vi) intelligent vehicle highway system information, (vii) a vehicle radio control setting, (viii) a vehicle environmental system setting, (ix) vehicle speed, (x) vehicle heading, (xi) turn signal indicators and (xii) a radio setting, (b) content displayed by said display screen of said reconfigurable display device is user-selectable, (c) content displayed by said display screen of said reconfigurable display device is user-selectable via at least one of a keypad and a trackball, and (d) content displayed by said display screen of said reconfigurable display device is user-selectable via an input device located at a steering column of the equipped vehicle or at a dashboard of the equipped vehicle.

59 (original): The vehicular multi-camera vision system of claim 49, wherein at least one of (a) said reconfigurable display device comprises a flat-panel display device, (b) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a back-lit liquid crystal display device, (c) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a plasma display device, (d) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a light-emitting diode display device, (e) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device is mounted at a dashboard of the equipped vehicle and (f) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device is mounted at a facia of the equipped vehicle.

60 (original): The vehicular multi-camera vision system of claim 49, wherein at least one of (a) each of said at least three image capture devices comprises an array of photosensing pixels and wherein a mosaic spectral filter masks incident radiation in order to produce pixels which respond respectively to red, green and blue light and (b) each of said at least three image capture devices comprises an array of photosensing pixels and comprises filtering to least one of (i) at least partially block near infrared radiation from pixels of said array and (ii) at least partially block infrared radiation from pixels of said array.

61 (currently amended): The vehicular multi-camera vision system of claim 49, wherein at least one of (a) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle into a loading dock, (b) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle with a trailer attached thereto, (c) said vehicular multi-camera vision system provides accident monitoring, (d) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and (e) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and to deploy a smart headrest in such an event.

62 (original): The vehicular multi-camera vision system of claim 49, wherein said first field of view said first image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom and wherein said second field of view said second image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom.

63 (original): The vehicular multi-camera vision system of claim 49, wherein said display device comprises a circular polarizer.

64 (original): The vehicular multi-camera vision system of claim 49, wherein at least one of (a) said synthesized image displayed by said display screen approximates a panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle, (b) said synthesized image displayed by said display screen approximates a substantially seamless panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle and (c) said synthesized image displayed by said display screen approximates a substantially seamless view as would be viewed from a single virtual camera located exterior the equipped vehicle.

65 (original): A multi-camera vision system for a vehicle, said vehicular multi-camera vision system comprising:

at least three image capture devices disposed at a vehicle equipped with said vehicular multi-camera vision system;

said at least three image capture devices comprising a first image capture device disposed at a driver-side portion of the equipped vehicle at a first location;

said at least three image capture devices comprising a second image capture device disposed at a passenger-side portion of the equipped vehicle at a second location;

said at least three image capture devices comprising a third image capture device disposed at a rear portion of the equipped vehicle at a third location;

wherein said first image capture device has a first field of view exterior of the equipped vehicle;

wherein said second image capture device has a second field of view exterior of the equipped vehicle;

wherein said third image capture device has a third field of view exterior of the equipped vehicle;

wherein said first field of view of said first image capture device overlaps with said third field of view of said third image capture device defining a first overlap zone;

wherein said second field of view of said second image capture device overlaps with said third field of view of said third image capture device defining a second overlap zone;

wherein said first image capture device captures first image data;

wherein said second image capture device captures second image data;

wherein said third image capture device captures second image data;

wherein each of said at least three image capture devices comprises a CMOS imaging array;

wherein said third vehicular camera disposed at the rear of the equipped vehicle is operable as a backup camera;

an image processor;

wherein first image data captured by said first image capture device is received at said image processor;

wherein second image data captured by said second image capture device is received at said image processor;

wherein third image data captured by said third image capture device is received at said image processor;

wherein, responsive to processing by said image processor of received image data, a synthesized image is generated without duplication of objects present in said first overlap zone and in said second overlap zone and wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle; and

wherein said synthesized image is displayed by a single display screen of a reconfigurable display device that is viewable by a driver of the equipped vehicle when normally operating the equipped vehicle.

66 (original): The vehicular multi-camera vision system of claim 65, wherein at least one of (a) first image data captured by said first image capture device is received at said image processor via a digital data stream and wherein second image data captured by said second image capture device is received at said image processor via a digital data stream and wherein third image data captured by said third image capture device is received at said image processor via a digital data stream and (b) image data transmission from said first, second and third image capture devices to said image processor is by electrically conductive leads over a vehicle communication bus.

67 (original): The vehicular multi-camera vision system of claim 65, wherein the image displayed by said display screen includes a visual indication of the location of the equipped vehicle in said view and wherein at least one of (a) said visual indication approximates the footprint occupied by the equipped vehicle and (b) wherein said visual indication comprises an outline of an area substantially occupied by the equipped vehicle.

68 (original): The vehicular multi-camera vision system of claim 65, wherein said first image capture device is disposed at the equipped vehicle at substantially the same height relative to ground as is said second image capture device, and wherein said first location where said first image capture device is disposed at the driver-side of the equipped vehicle is a first distance forward of where the driver sits when operating the equipped vehicle and wherein said second location where said second image capture device is disposed at the passenger-side of the equipped vehicle is a second distance forward of where the driver sits when operating the equipped vehicle, and wherein said first distance is substantially the same as said second distance, and wherein said third image capture device is at a height relative to ground that is lower than the height relative to ground of said first and second image capture devices, and wherein said third location is a third distance rearward of where the driver sits when operating the

equipped vehicle and wherein said third distance is larger than either of said first and second distances.

69 (original): The vehicular multi-camera vision system of claim 65, wherein at least one of (a) said at least three image capture devices have the principal axis of their respective field of view aimed along non-parallel axes and (b) said display device comprises a circular polarizer.

70 (original): The vehicular multi-camera vision system of claim 65, wherein the image displayed by said display screen comprises a graphic overlay and wherein at least one of (i) said graphic overlay comprises indicia of the anticipated path of travel of the equipped vehicle and (ii) said graphic overlay comprises indicia indicating distance to objects exterior the equipped vehicle.

71 (original): The vehicular multi-camera vision system of claim 65, wherein at least one of (a) the image displayed by said display screen comprises enhancements that assist visually distinguishing objects close to the equipped vehicle, (b) the image displayed by said display screen comprises indicia and wherein said indicia responds to at least one of the vehicle's steering system, the vehicle's differential system and a compass, (c) at least one of color and flashing is used to draw the driver's attention to a potential hazard present in the image displayed by said display screen and (d) the image displayed by said display screen comprises a graphic overlay that includes indicia of the anticipated path of travel of the equipped vehicle and wherein said graphic overlay is disabled when the vehicle's gear actuator is not in reverse gear.

72 (original): The vehicular multi-camera vision system of claim 65, wherein at least one of (a) the display luminance of said display screen of said reconfigurable display device is variable responsive to a sensing of an ambient light level and (b) the display

luminance of said display screen of said reconfigurable display device is variable responsive to at least one of (i) a vehicle headlight activation control, (ii) an ambient light sensor and (iii) an indication of ambient light level detected by at least one of said first, second and third image capture devices.

73 (original): The vehicular multi-camera vision system of claim 65, wherein at least one of (a) said display screen of said reconfigurable display device is operable to display at least one of (i) pager information, (ii) a telephone number listing, (iii) global positioning system data, (iv) a map, (v) route guidance information, (vi) intelligent vehicle highway system information, (vii) a vehicle radio control setting, (viii) a vehicle environmental system setting, (ix) vehicle speed, (x) vehicle heading, (xi) turn signal indicators and (xii) a radio setting, (b) content displayed by said display screen of said reconfigurable display device is user-selectable, (c) content displayed by said display screen of said reconfigurable display device is user-selectable via at least one of a keypad and a trackball, (d) content displayed by said display screen of said reconfigurable display device is user-selectable via an input device located at a steering column of the equipped vehicle or at a dashboard of the equipped vehicle, (e) said reconfigurable display device comprises a flat-panel display device, (f) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a back-lit liquid crystal display device, (g) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a plasma display device, (h) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a light-emitting diode display device, (i) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device is mounted at a dashboard of the equipped vehicle and (j) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device is mounted at a facia of the equipped vehicle.

74 (original): The vehicular multi-camera vision system of claim 65, wherein at least one of (a) each of said at least three image capture devices comprises an array of photosensing pixels and wherein a mosaic spectral filter masks incident radiation in order to produce pixels which respond respectively to red, green and blue light and (b) each of said at least three image capture devices comprises an array of photosensing pixels and comprises filtering to least one of (i) at least partially block near infrared radiation from pixels of said array and (ii) at least partially block infrared radiation from pixels of said array.

75 (original): The vehicular multi-camera vision system of claim 65, wherein at least one of (a) said synthesized image displayed by said display screen approximates a panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle, (b) said synthesized image displayed by said display screen approximates a substantially seamless panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle and (c) said synthesized image displayed by said display screen approximates a substantially seamless view as would be viewed from a single virtual camera located exterior the equipped vehicle.

76 (currently amended): The vehicular multi-camera vision system of claim 65, wherein at least one of (a) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle into a loading dock, (b) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle with a trailer attached thereto, (c) said vehicular multi-camera vision system provides accident monitoring, (d) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and (e) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and to deploy a smart headrest in such an event.

77 (original): The vehicular multi-camera vision system of claim 65, wherein said first field of view said first image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom and wherein said second field of view said second image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom.

78 (original): A multi-camera vision system for a vehicle, said vehicular multi-camera vision system comprising:

at least three image capture devices disposed at a vehicle equipped with said vehicular multi-camera vision system;

said at least three image capture devices comprising a first image capture device disposed at a driver-side portion of the equipped vehicle at a first location;

said at least three image capture devices comprising a second image capture device disposed at a passenger-side portion of the equipped vehicle at a second location;

said at least three image capture devices comprising a third image capture device disposed at a rear portion of the equipped vehicle at a third location;

wherein said first image capture device has a first field of view exterior of the equipped vehicle;

wherein said second image capture device has a second field of view exterior of the equipped vehicle;

wherein said third image capture device has a third field of view exterior of the equipped vehicle;

wherein said first field of view of said first image capture device overlaps with said third field of view of said third image capture device defining a first overlap zone;

wherein said second field of view of said second image capture device overlaps with said third field of view of said third image capture device defining a second overlap zone;

wherein said first field of view said first image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom and wherein said second field of view said second image capture device is bounded by the side of the equipped vehicle it is disposed at and extends outwards therefrom;

wherein said first image capture device captures first image data;

wherein said second image capture device captures second image data;

wherein said third image capture device captures second image data;

wherein each of said at least three image capture devices comprises a CMOS imaging array;

wherein said third vehicular camera disposed at the rear of the equipped vehicle is operable as a backup camera;

an image processor;

wherein first image data captured by said first image capture device is received at said image processor;

wherein second image data captured by said second image capture device is received at said image processor;

wherein third image data captured by said third image capture device is received at said image processor;

wherein, responsive to processing by said image processor of received image data, a synthesized image is generated without duplication of objects present in said first overlap zone and in said second overlap zone and wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle;

wherein said synthesized image is displayed by a single display screen of a reconfigurable display device that is viewable by a driver of the equipped vehicle when normally operating the equipped vehicle;

wherein at least one of (a) first image data captured by said first image capture device is received at said image processor via a digital data stream and wherein second image data captured by said second image capture device is received at said image processor via a digital data stream and wherein third image data captured by said third image capture device is received at said image processor via a digital data stream and (b) image data transmission from said first, second and third image capture devices to said image processor is by electrically conductive leads over a vehicle communication bus; and

wherein at least one of (a) said synthesized image displayed by said display screen approximates a panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle, (b) said synthesized image displayed by said display screen approximates a substantially seamless panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle and (c) said synthesized image displayed by said display screen approximates a substantially seamless view as would be viewed from a single virtual camera located exterior the equipped vehicle.

79 (original): The vehicular multi-camera vision system of claim 78, wherein the image displayed by said display screen includes a visual indication of the location of the equipped vehicle in said view and wherein at least one of (a) said visual indication approximates the footprint occupied by the equipped vehicle and (b) wherein said visual indication comprises an outline of an area substantially occupied by the equipped vehicle.

80 (original): The vehicular multi-camera vision system of claim 78, wherein said first image capture device is disposed at the equipped vehicle at substantially the same height relative to ground as is said second image capture device, and wherein said first location where said first image capture device is disposed at the driver-side of the equipped vehicle is a first distance forward of where the driver sits when operating the equipped vehicle and wherein said second location where said second image capture device is disposed at the passenger-side of the equipped vehicle is a second distance forward of where the driver sits when operating the equipped vehicle, and wherein said first distance is substantially the same as said second distance, and wherein said third image capture device is at a height relative to ground that is lower than the height relative to ground of said first and second image capture devices, and wherein said third location is a third distance rearward of where the driver sits when operating the equipped vehicle and wherein said third distance is larger than either of said first and second distances.

81 (original): The vehicular multi-camera vision system of claim 78, wherein the image displayed by said display screen comprises a graphic overlay and wherein at least one of (i) said graphic overlay comprises indicia of the anticipated path of travel of the equipped vehicle and (ii) said graphic overlay comprises indicia indicating distance to objects exterior the equipped vehicle.

82 (original): The vehicular multi-camera vision system of claim 78, wherein at least one of (a) the image displayed by said display screen comprises enhancements that assist visually distinguishing objects close to the equipped vehicle, (b) the image displayed by said display screen comprises indicia and wherein said indicia responds to at least one of the vehicle's steering system, the vehicle's differential system and a compass, (c) at least one of color and flashing is used to draw the driver's attention to a potential hazard present in the image displayed by said display screen and (d) the

image displayed by said display screen comprises a graphic overlay that includes indicia of the anticipated path of travel of the equipped vehicle and wherein said graphic overlay is disabled when the vehicle's gear actuator is not in reverse gear.

83 (original): The vehicular multi-camera vision system of claim 78, wherein at least one of (a) the display luminance of said display screen of said reconfigurable display device is variable responsive to a sensing of an ambient light level and (b) the display luminance of said display screen of said reconfigurable display device is variable responsive to at least one of (i) a vehicle headlight activation control, (ii) an ambient light sensor and (iii) an indication of ambient light level detected by at least one of said first, second and third image capture devices.

84 (original): The vehicular multi-camera vision system of claim 78, wherein at least one of (a) said display screen of said reconfigurable display device is operable to display at least one of (i) pager information, (ii) a telephone number listing, (iii) global positioning system data, (iv) a map, (v) route guidance information, (vi) intelligent vehicle highway system information, (vii) a vehicle radio control setting, (viii) a vehicle environmental system setting, (ix) vehicle speed, (x) vehicle heading, (xi) turn signal indicators and (xii) a radio setting, (b) content displayed by said display screen of said reconfigurable display device is user-selectable, (c) content displayed by said display screen of said reconfigurable display device is user-selectable via at least one of a keypad and a trackball, (d) content displayed by said display screen of said reconfigurable display device is user-selectable via an input device located at a steering column of the equipped vehicle or at a dashboard of the equipped vehicle, (e) said reconfigurable display device comprises a flat-panel display device, (f) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a back-lit liquid crystal display device, (g) said reconfigurable display device comprises a flat-panel display device and wherein said

flat-panel display device comprises a plasma display device, (h) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device comprises a light-emitting diode display device, (i) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device is mounted at a dashboard of the equipped vehicle and (j) said reconfigurable display device comprises a flat-panel display device and wherein said flat-panel display device is mounted at a facia of the equipped vehicle.

85 (original): The vehicular multi-camera vision system of claim 78, wherein at least one of (a) each of said at least three image capture devices comprises an array of photosensing pixels and wherein a mosaic spectral filter masks incident radiation in order to produce pixels which respond respectively to red, green and blue light and (b) each of said at least three image capture devices comprises an array of photosensing pixels and comprises filtering to least one of (i) at least partially block near infrared radiation from pixels of said array and (ii) at least partially block infrared radiation from pixels of said array.

86 (currently amended): The vehicular multi-camera vision system of claim 78, wherein at least one of (a) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle into a loading dock, (b) said vehicular multi-camera vision system provides guidance when backing the equipped vehicle with a trailer attached thereto, (c) said vehicular multi-camera vision system provides accident monitoring, (d) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and (e) said vehicular multi-camera vision system is operable to alert the driver of the equipped vehicle to an impending rear-end collision and to deploy a smart headrest in such an event.

Remarks:

Review of the specification revealed that the specification needed updating to reference the patent number of an incorporated parent application, which has now issued as a United States patent. Claims 1, 41, 61, 76 and 86 have also been amended to correct clerical errors.

Because the present amendment relates to matters of form only, and does not require any further search on the part of the Examiner, it is respectfully submitted that it is proper for entry and such entry is requested along with a notice of approval of the amendment.

Respectfully submitted,

Date: December 12, 2013

Timothy A. Flory
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Grand Rapids, Michigan 49546
(616) 975-5500

Electronic Acknowledgement Receipt

EFS ID:	17640474
Application Number:	13800691
International Application Number:	
Confirmation Number:	4472
Title of Invention:	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE
First Named Inventor/Applicant Name:	Kenneth Schofield
Customer Number:	15671
Filer:	Timothy A. Flory/Amanda Sytsma
Filer Authorized By:	Timothy A. Flory
Attorney Docket Number:	MAG04 P-2059
Receipt Date:	12-DEC-2013
Filing Date:	13-MAR-2013
Time Stamp:	14:00:25
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	TransmittalForm.pdf	119918 67543b48109c67e699e501d1274b376c0d570b26	no	1
Warnings:					
Information:					

2	Amendment after Notice of Allowance (Rule 312)	AmendmentAfterAllowance.pdf	102598 839639701b904261eb70b21668d5351cbefc1852	no	30

Warnings:	
Information:	
Total Files Size (in bytes):	222516

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Doc Code: TRAN.LET

Document Description: Transmittal Letter

PTO/SB/21 (07-09)
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TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Total Number of Pages in This Submission

Application Number	13/800,691
Filing Date	March 13, 2013
First Named Inventor	Kenneth Schofield
Art Unit	2486
Examiner Name	Anand Shashikant Rao
Attorney Docket Number	MAG04 P-2059

ENCLOSURES (*Check all that apply*)

- ☐ Fee Transmittal Form
  - ☐ Fee Attached
- ☐ Amendment/Reply
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
- ☐ Extension of Time Request
- ☐ Express Abandonment Request
- ☐ Information Disclosure Statement
- ☐ Certified Copy of Priority Document(s)
- ☐ Reply to Missing Parts/ Incomplete Application
  - ☐ Reply to Missing Parts under 37 CFR 1.52 or 1.53
- ☐ Drawing(s)
- ☐ Licensing-related Papers
- ☐ Petition
- ☐ Petition to Convert to a Provisional Application
- ☐ Power of Attorney, Revocation
- ☐ Change of Correspondence Address
- ☐ Terminal Disclaimer
- ☐ Request for Refund
- ☐ CD, Number of CD(s) _____
  - ☐ Landscape Table on CD
- ☐ After Allowance Communication to TC
- ☐ Appeal Communication to Board of Appeals and Interferences
- ☐ Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- ☐ Proprietary Information
- ☐ Status Letter
- ☑ Other Enclosure(s) (please Identify below):

AMENDMENT AFTER ALLOWANCE UNDER 37 CFR 1.312

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	GARDNER, LINN, BURKHART & FLORY, LLP		
Signature	/taf/		
Printed name	Timothy A . Flory		
Date	December 12, 2013	Reg. No.	42540

CERTIFICATE OF TRANSMISSION/MAILING

I hereby certify that this correspondence is being facsimile transmitted to the USPTO or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below:

Signature	/ars/		
Typed or printed name	Amanda R. Sytsma	Date	December 12, 2013

This collection of information is required by 37 CFR 1.5. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and1.14. This collection is estimated to 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PATENT
MAG04 P2059

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventors : Kenneth Schofield, Mark L. Larson and Keith J. Vadas
Serial No. : 13/800,691
Filing Date : March 13, 2013
For : MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

Notice of Allowance Mailing Date: December 11, 2013
Confirmation No.: 4472

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

RESPONSE TO INFORMATIONAL NOTICE TO APPLICANT

Responsive to the Informational Notice to Applicant mailed April 22, 2013, enclosed herewith are newly signed Declarations. Entry and approval of these signed Declarations is respectfully requested.

Respectfully submitted,

Date: December 16, 2013

Timothy A. Flory
Registration No. 42 540
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Drive, S.E., Suite 207
Grand Rapids, Michigan 49546
(616) 975-5500

PTO/AIA/01 (06-12)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

As the below named inventor, I hereby declare that:

This declaration is directed to:

☐ The attached application, or

☑ United States application or PCT international application number 13/800,691 filed on March 13, 2013.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: Kenneth Schofield Date (Optional): _____

Signature: K. Schofield

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional PTO/SB/AIA01 form for each additional inventor.

PTO/AIA/01 (06-12)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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Title of Invention	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

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- ☑ United States application or PCT international application number 13/800,691 filed on March 13, 2013.

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LEGAL NAME OF INVENTOR

Inventor: Mark L. Larson Date (Optional): 6-18-2013

Signature: _____

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional PTO/SB/AIA01 form for each additional inventor.

PTO/AIA/01 (06-12)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

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LEGAL NAME OF INVENTOR

Inventor: Keith J. Vadas Date (Optional): 12/14/13

Signature: Keith J. Vadas

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional PTO/SB/AIA01 form for each additional inventor.

Electronic Acknowledgement Receipt

EFS ID:	17663036
Application Number:	13800691
International Application Number:	
Confirmation Number:	4472
Title of Invention:	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE
First Named Inventor/Applicant Name:	Kenneth Schofield
Customer Number:	15671
Filer:	Timothy A. Flory/Amanda Sytsma
Filer Authorized By:	Timothy A. Flory
Attorney Docket Number:	MAG04 P-2059
Receipt Date:	16-DEC-2013
Filing Date:	13-MAR-2013
Time Stamp:	14:29:05
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	ResponsetoInformationalNotice.pdf	15423 38ceecdfe60b7ebbdb6db1589e2b4adb3d07f83e	no	1

Warnings:	
Information:	

2	Oath or Declaration filed	Declarations.pdf	645469 1081378849ab5fbbd847aadfdfe445c0435b97c9	no	3

Warnings:	
Information:	
Total Files Size (in bytes):	660892

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New Applications Under 35 U.S.C. 111
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National Stage of an International Application under 35 U.S.C. 371
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New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
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INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

15671 7590 12/11/2013
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr., SE, Suite 207
Grand Rapids, MI 49546

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

Amanda R. Sytsma	(Depositor's name)
/ars/	(Signature)
December 18, 2013	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/800,691	03/13/2013	Kenneth Schofield	MAG04 P-2059	4472

TITLE OF INVENTION: MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1780	$300	$0	$2080	03/11/2014

EXAMINER	ART UNIT	CLASS-SUBCLASS
RAO, ANAND SHASHIKANT	2486	348-148000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 GARDNER, LINN, BURKHART & FLORY, LLP
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: MAGNA ELECTRONICS INC.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): AUBURN HILLS, MI

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

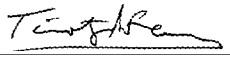
4a. The following fee(s) are submitted:
- ☒ Issue Fee
- ☒ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 50-5553 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29	NOTE: Absent a valid certification of Micro Entity Status (see form PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
❑ Applicant asserting small entity status. See 37 CFR 1.27	NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
❑ Applicant changing to regular undiscounted fee status.	NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature  Date December 18, 2013

Typed or printed name Timothy A. Flory Registration No. 42540

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Electronic Patent Application Fee Transmittal

Application Number:	13800691
Filing Date:	13-Mar-2013
Title of Invention:	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE
First Named Inventor/Applicant Name:	Kenneth Schofield
Filer:	Timothy A. Flory/Amanda Sytsma
Attorney Docket Number:	MAG04 P-2059

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl Issue Fee	1501	1	1780	1780
Publ. Fee- Early, Voluntary, or Normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**2080**

Electronic Acknowledgement Receipt

EFS ID:	17677111
Application Number:	13800691
International Application Number:	
Confirmation Number:	4472
Title of Invention:	MULTI-CAMERA VISION SYSTEM FOR A VEHICLE
First Named Inventor/Applicant Name:	Kenneth Schofield
Customer Number:	15671
Filer:	Timothy A. Flory/Amanda Sytsma
Filer Authorized By:	Timothy A. Flory
Attorney Docket Number:	MAG04 P-2059
Receipt Date:	18-DEC-2013
Filing Date:	13-MAR-2013
Time Stamp:	16:36:35
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$2080
RAM confirmation Number	4455
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Issue Fee Payment (PTO-85B)	IssueFeeTransmittal.pdf	196062 58fc532e650dcc148e9ac6edcb84c13c53a0ce92	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	32005 391f65a9d2829568d127ddb98f791337dc977c32	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	228067	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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BIB DATA SHEET

CONFIRMATION NO. 4472

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/800,691	03/13/2013 RULE	348	2486	MAG04 P-2059

APPLICANTS

DONNELLY CORPORATION, Holland, MI

INVENTORS

Kenneth Schofield, Holland, MI;
Mark L. Larson, Grand Haven, MI;
Keith J. Vadas, Coopersville, MI;

**** CONTINUING DATA ***************************

This application is a CON of 12/688,146 01/15/2010
which is a CON of 12/496,357 07/01/2009 PAT 8462204
which is a CON of 11/122,880 05/05/2005 PAT 7561181
which is a CON of 10/324,679 12/20/2002 PAT 6891563
which is a CON of 08/952,026 11/19/1997 PAT 6498620
which is a 371 of PCT/US1996/007382 05/22/1996

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

04/15/2013

Foreign Priority claimed	☐ Yes ☑ No	☐ Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
35 USC 119(a-d) conditions met	☐ Yes ☑ No		MI	13	86	4
Verified and Acknowledged	/ANDY SHASHIKANT RAO/ Examiner's Signature	AR Initials				

ADDRESS

Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr., SE, Suite 207
Grand Rapids, MI 49546
UNITED STATES

TITLE

MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

FILING FEE RECEIVED		
5902	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

BIB (Rev. 05/07).

PATENT
MAG04 P-2059

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group Art : 2486
Examiner : Anand S. Rao
Inventors : Kenneth Schofield, Mark L. Larson and Keith J. Vadas
Serial No. : 13/800,691
Filing Date : March 13, 2013
For : MULTI-CAMERA VISION SYSTEM FOR A VEHICLE

Confirmation No.: 4472
Notice of Allowance Mailing Date: December 11, 2013

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

OK TO ENTER: /A.R./ (01/02/2014)

AMENDMENT AFTER ALLOWANCE UNDER 37 CFR 1.312

Receipt of the Notice of Allowability and the Notice of Allowance and Fee(s) Due and Examiner's Amendment mailed December 11, 2013 in connection with the above identified application is hereby acknowledged.

Amendments to the Specification are on page 2 of this paper.

Amendments to the Claims are reflected in the listing of claims that begins on page 3 of this paper.

Remarks are on page 30 of this paper.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/800,691	03/13/2013	Kenneth Schofield	MAG04 P-2059	4472

15671 7590 01/08/2014

Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr., SE, Suite 207
Grand Rapids, MI 49546

EXAMINER	
RAO, ANAND SHASHIKANT	
ART UNIT	PAPER NUMBER
2486	

NOTIFICATION DATE	DELIVERY MODE
01/08/2014	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

sytsma@glbf.com
patents@glbf.com
clark@glbf.com

Response to Rule 312 Communication	Application No.	Applicant(s)
	13/800,691	SCHOFIELD ET AL.
	Examiner	Art Unit
	ANDY RAO	2486

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address –

1. ☒ The amendment filed on *12/12/13* under 37 CFR 1.312 has been considered, and has been:

   a) ☒ entered.

   b) ☐ entered as directed to matters of form not affecting the scope of the invention.

   c) ☐ disapproved because the amendment was filed after the payment of the issue fee.
   Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.

   d) ☐ disapproved. See explanation below.

   e) ☐ entered in part. See explanation below.

/ANDY RAO/
Primary Examiner, Art Unit 2486

PTO/SB/08A (07-05)
Approved for use through 07/31/2006. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known	
Application Number	13/800,691
Filing Date	March 13, 2013
First Named Inventor	Kenneth Schofield
Art Unit	2486
Examiner Name	Anand Shashikant Rao
Attorney Docket Number	MAG04 P-2059

Sheet 13 of 17

U. S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		4,600,913	07-15-1986	Caine	
		4,580,875	04-08-1986	Bechtel	
		4,572,619	02-25-1986	Reininger	
		4,571,082	02-18-1986	Downs	
		4,549,208	10-22-1985	Kamejima et al.	
		4,546,551	10-15-1985	Franks	
		4,529,873	07-16-1985	Ballmer	
		4,529,275	07-16-1985	Ballmer	
		4,512,637	04-23-1985	Ballmer	
		4,491,390	01-01-1985	Tong-Shen	
		4,481,450	11-06-1984	Watanabe et al.	
		4,460,831	07-17-1984	Oettinger et al.	
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		4,431,896	02-14-1984	Lodetti	
		4,420,238	12-13-1983	Felix	
		4,381,888	05-03-1983	Momiyama	
		4,357,558	11-02-1982	Massoni et al.	
		4,355,271	10-19-1982	Noack	
		4,288,814	09-08-1981	Talley et al.	
		4,281,898	08-04-1981	Ochiai	
		4,277,804	07-07-1981	Robison	
		4,266,856	05-12-1981	Wainwright	
		4,249,160	02-03-1981	Chilvers	
		4,247,870	01-27-1981	Gabel et al.	
		4,236,099	11-25-1980	Rosenblum	
		4,218,698	08-19-1980	Bart et al.	
		4,214,266	07-22-1980	Myers	
		4,200,361	04-29-1980	Malvano	
		3,985,424	10-12-1976	Steinacher	
		2012/0045112	02-23-2012	Lundblad et al.	
		2009/0256938	~~04-09-2008~~	Bechtel et al.	October 15, 2009
		2009/0160987	~~12-21-2007~~	Bechtel et al.	June 25, 2009
		2009/0113509	04-30-2009	Tseng et al.	

Change(s) applied to document, /D.D./ 1/3/2014

Examiner Signature	/Anand Rao/ (12/06/2013)	Date Considered	12/06/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation it not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R./

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/800,691	02/04/2014	8643724	MAG04 P-2059	4472

15671 7590 01/15/2014

Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Dr., SE, Suite 207
Grand Rapids, MI 49546

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Kenneth Schofield, Holland, MI;
Mark L. Larson, Grand Haven, MI;
Keith J. Vadas, Coopersville, MI;
DONNELLY CORPORATION, Holland, MI

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF MICHIGAN

Magna Electronics Inc.

Plaintiff(s),

v.

Valeo, Inc. et al

Defendant(s).
_____/

Case No. 2:14-cv-14-10540

Judge Denise Page Hood

Magistrate Judge Laurie J. Michelson

REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court, Eastern District of Michigan, on the following ☑ Patents or ☐ Trademarks

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	8,643,724	02/04/2014	Manga Electronics Inc.
2			
3			
4			
5			
6			
7			
8			
9			
10			

To list additional patent/trademark numbers, please attach another page with the number, date and holder.

Date: February 5, 2014

/s/Terence J. Linn
P33449
Gardner, Linn, Burkhart & Flory, LLP
2851 Charlevoix Drive SE, Ste 207
Grand Rapids,MI 49546
616-975-5500
linn@glbf.com

The United States Patent and Trademark Office
PATENT TRIAL AND APPEAL BOARD

A petition has been filed in Patent 8,643,724 on November 7, 2014.

The Case Number is IPR2015-00253.

To view the documents filed in this petition, go to www.uspto.gov/ptab and click on the Direct Link.

Click on Search for a proceeding / Browse the proceedings and enter the Patent Number or the Trial or Case Number and select the Search button.

Questions regarding this notice should be directed to the Patent Trial and Appeal Board at 571-272-7822.

Trials@uspto.gov
571.272.7822

Paper 7
Entered: May 13, 2015

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

VALEO NORTH AMERICA, INC., VALEO S.A., VALEO GMBH, VALEO SCHALTER UND SENSOREN GMBH, AND CONNAUGHT ELECTRONICS LTD.,
Petitioner,

v.

MAGNA ELECTRONICS, INC.,
Patent Owner.

Case IPR2015-00253
U.S. Patent No. 8,643,724 B2

Before RICHARD E. RICE, JAMES A. TARTAL, and BARBARA A. PARVIS, *Administrative Patent Judges.*

PARVIS, *Administrative Patent Judge.*

DECISION
Denying Institution of *Inter Partes* Review
37 C.F.R. § 42.108

I. INTRODUCTION

A. Background

Valeo North America, Inc., Valeo S.A., Valeo GmbH, Valeo Schalter Und Sensoren GmbH, and Connaught Electronics Ltd. ("Petitioner") filed a Petition (Paper 1, "Pet.") requesting an *inter partes* review of claims 49–86

("challenged claims") of U.S. Patent No. 8,643,724 B2 (Exhibit 1001, "the '724 Patent"). Magna Electronics, Inc. ("Patent Owner") filed a Preliminary Response. Paper 6 ("Prelim. Resp."). We have jurisdiction under 35 U.S.C. § 314, which provides that an *inter partes* review may not be instituted unless "the information presented in the petition . . . and any [preliminary] response . . . shows that there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition." 35 U.S.C. § 314(a).

Based on our review of the record, we determine that Petitioner has not established a reasonable likelihood that it would prevail with respect to any of the challenged claims.

B. Related Proceedings

Petitioner and Patent Owner identify, as related proceedings, a district court case involving alleged infringement of the '724 Patent, which is *Magna Electronics Inc. v. Valeo, Inc.*, No. 2:14-cv-10540 (E.D. Mich.). Pet. 4; *see* Magna Electronics, Inc.'s Mandatory Notices Pursuant to 37 C.F.R. § 42.8 ("Patent Owner Notice," Paper 4).

C. The '724 Patent

The '724 Patent relates to multi-camera vision systems for vehicles. *See generally* Ex. 1001, Abstract. According to the '724 Patent, a long-felt need in the art of vehicle rearview vision systems has been to eliminate exterior rearview mirrors by using image capture devices, such as cameras, in combination with dashboard displays. *Id.* at 1:43–46. Prior art camera-based systems, however, had not obtained commercial acceptance because they presented too much information in a confusing manner. *Id.* at 1:60–64.

To address these issues, the '724 Patent describes a rearview vision system having two side image capture devices positioned, respectively, on opposite sides of the vehicle and a center image capture device disposed at a rear portion of the vehicle. *Id.* at 5:53–58. The '724 Patent describes techniques for synthesizing images captured by these image capture devices to form a view as would be seen from a camera at a single location and that is displayed to the driver. *See e.g., id.* at 3:12–25.

Figure 3, reproduced below, depicts a display according to the invention.

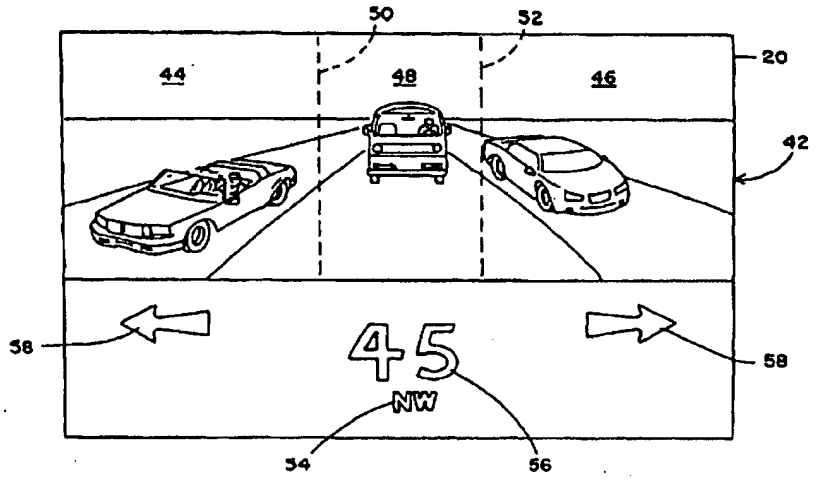

FIG. 3

Figure 3 illustrates image display device 20 displaying composite image 42.

As shown in Figure 3, composite image 42 is made up of left image portion 44, right image portion 46, and center image portion 48. *Id.* at 7:44–46. The image portions at boundaries 50 and 52 are continuous such that composite image 42 is a seamless panoramic view rearwardly of the vehicle. *Id.* at 7:55–58. Composite image 42 provides a clear image that avoids

confusion and simplifies the task of extracting information from the multiple image portions. *Id.* at 7:64–67.

D. *Illustrative Claim*

Claims 49, 65, and 78 are the only independent claims challenged by Petitioner ("challenged independent claims"). We do not address the additional prior art or grounds of unpatentability Petitioner asserts against dependent claims 50–64, 66–77, and 79–86 because Petitioner has not established a reasonable likelihood that it would prevail with respect to claims 49, 65, and 78, from which each of claims 50–64, 66–77, and 79–86 depends, respectively. Claim 49 is illustrative and is reproduced below:

> 49. A multi-camera vision system for a vehicle, said vehicular multi-camera vision system comprising:
>
> at least three image capture devices disposed at a vehicle equipped with said vehicular multi-camera vision system;
>
> said at least three image capture devices comprising a first image capture device disposed at a driver-side portion of the equipped vehicle at a first location;
>
> said at least three image capture devices comprising a second image capture device disposed at a passenger-side portion of the equipped vehicle at a second location;
>
> said at least three image capture devices comprising a third image capture device disposed at a rear portion of the equipped vehicle at a third location;
>
> wherein said first image capture device has a first field of view exterior of the equipped vehicle;
>
> wherein said second image capture device has a second field of view exterior of the equipped vehicle;
>
> wherein said third image capture device has a third field of view exterior of the equipped vehicle;
>
> wherein said first field of view of said first image capture device overlaps with said third field of view of said third image capture device defining a first overlap zone;

wherein said second field of view of said second image capture device overlaps with said third field of view of said third image capture device defining a second overlap zone;

wherein said first image capture device captures first image data;

wherein said second image capture device captures second image data;

wherein said third image capture device captures second image data;

wherein each of said at least three image capture devices comprises a CMOS imaging array;

wherein said first image capture device is disposed at the equipped vehicle at substantially the same height relative to ground as is said second image capture device;

wherein said third vehicular camera disposed at the rear of the equipped vehicle is operable as a back-up camera;

an image processor;

wherein first image data captured by said first image capture device is received at said image processor;

wherein second image data captured by said second image capture device is received at said image processor;

wherein third image data captured by said third image capture device is received at said image processor;

wherein, responsive to processing by said image processor of received image data, a synthesized image is generated without duplication of objects present in said first overlap zone and in said second overlap zone and wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle;

wherein said synthesized image is displayed by a single display screen of a reconfigurable display device that is viewable by a driver of the equipped vehicle when normally operating the equipped vehicle; and

wherein at least one of (a) said synthesized image displayed by said display screen approximates a panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle, (b) said synthesized image displayed by said display screen approximates a substantially

seamless panoramic view as would be viewed from a single virtual camera located exterior the equipped vehicle and (c) said synthesized image displayed by said display screen approximates a substantially seamless view as would be viewed from a single virtual camera located exterior the equipped vehicle.

E. *The Asserted Prior Art*

Petitioner relies upon the prior art references below in its challenge of independent claims 49, 65, and 78. Pet. 8.

Reference	Patent No. or Publication No.	Issued, Filed, or Published Date	Exhibit No.
Lemelson	U.S. Patent No. 6,553,130 B1	Filed: June 28, 1996 Issued: Apr. 22, 2003	1002
Nissan	Japanese Publication No. JP H3-99952	Published: Apr. 25, 1991	1003 (1004)[1]
Aishin	Japanese Publication No. JPA64-14700	Publication: Jan. 18, 1989	1005 (1006)
Hino	Japanese Publication No. 62-16073	Published: Apr. 10, 1987	1007 (1008)
Wang[2]	Not Applicable.	May 27–31, 1991.	1009

F. *The Asserted Grounds of Unpatentability*

Petitioner challenges independent claims 49, 65, and 78 of the '724

[1] In parenthesis are Exhibit numbers of certified English translations of foreign language references. Citations herein are to the certified English translations.

[2] G. Wang, D. Renshaw, P.B. Denyer, and M. Lu, CMOS Video Cameras, Institute of Electrical and Electronics Engineers (IEEE), May 27-31, 1991 ("Wang," Ex. 1009).

Patent, under 35 U.S.C. § 103(a), as obvious over the combination of Nissan, Hino, Lemelson, Wang, and Aishin. Pet. 8. In support of this ground, Petitioner presents a Declaration by Dr. George Wolberg (Ex. 1019) and a Declaration by Dr. Ralph Wilhelm (Ex. 1020). Petitioner also asserts grounds of unpatentability for dependent claims 50–64, 66–77, and 79–86. Pet. 8.

II. ANALYSIS

A. Claim Construction

1. Legal Standard

In an *inter partes* review, claim terms in an unexpired patent are interpreted according to their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.300(b); *see also In re Cuozzo Speed Techs., LLC.*, 778 F.3d 1271, 1281–1282 (Fed. Cir. 2015) ("Congress implicitly adopted the broadest reasonable interpretation standard in enacting the AIA," and "the standard was properly adopted by [United States Patent and Trademark Office ('USPTO')] regulation."). Under the broadest reasonable construction standard, and absent any special definitions, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007) (quoting *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312 (Fed. Cir. 2005) (en banc)).

2. "said synthesized image"

The term "said synthesized image" is recited in each of the challenged independent claims. Neither party proposes a construction for that term. Patent Owner, however, contends that Nissan and Hino are insufficient to

teach "wherein *said synthesized image* approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle," as recited in the challenged independent claims. Prelim. Resp. 31. To evaluate Patent Owner's contention, we determine the broadest reasonable interpretation of "said synthesized image."

In each of the challenged independent claims, the antecedent basis for "said synthesized image" is within the following phrase: "wherein, responsive to processing by said image processor of received image data, *a synthesized image* is generated" (emphasis added). Accordingly, "said synthesized image" is generated by synthesizing the received image data captured by the image capture devices.

The '724 Patent Specification does not define "synthesized." A dictionary definition is useful in ascertaining the way in which one of ordinary skill in the art would use the term. *Starhome GmbH v. AT&T Mobility LLC*, 743 F.3d 849, 856–57 (Fed. Cir. 2014). The Chambers 21st Century Dictionary defines "synthesize" as "*to combine* (simple parts) to form (a complex whole)." *Chambers 21st Century Dictionary* (2001) *available at* http://search.credoreference.com/content/entry/chambdict/synthesize_or_synthesise/0 (retrieved on April 22, 2015) (Ex. 3001) (emphasis added).

The dictionary definition is consistent with the use of "synthesize" in the '724 Patent Specification. For instance, the '724 Patent Specification states, "[r]earview vision system 12 additionally includes [ ] image processor 18 for receiving data signals from image capture devices 14, 16 and *synthesizing, from the data signals*, [ ] composite image 42 which is displayed on [ ] display 20." Ex. 1001, 5:57–62 (emphasis added). The

'724 Patent Specification more particularly describes that the composite image is "*made up of*" image portions, and "[e]ach image portion 44–48 is reversed from the image as captured by the respective image capture device." *Id.* at 7:44–49 (emphasis added). Additionally, the '724 Patent Specification indicates that the synthesized image is generated by a "[c]ombined image generator." *Id.* at 11:34–35; *see also id.* at 12:29–31 ("[m]erging of multiple image portions would require additional combined image generators.")

Upon review, we determine that construing "said synthesized image" as "the image generated by combining the received image data captured by the image capture devices" is the broadest reasonable interpretation consistent with the '724 Patent Specification.

B. Asserted Obviousness of the Challenged Independent Claims

Petitioner contends that each of the challenged independent claims is unpatentable as obvious over the combination of Nissan, Hino, Lemelson, Wang, and Aishin. Pet. 24–32, 39–42, 45–48. In light of the arguments and evidence submitted, Petitioner has not established a reasonable likelihood that it would prevail with respect to its contentions that the challenged independent claims are unpatentable as obvious.

1. Nissan

Nissan teaches a device for displaying information about a vehicle's surroundings to the driver by using cameras. Ex. 1004, 2:16–20. Figure 1 of Nissan, reproduced below, illustrates placement of the cameras.

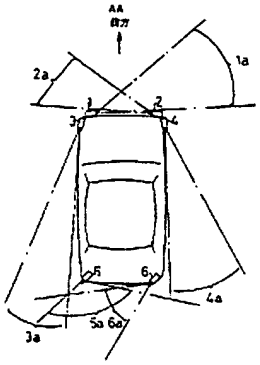

Figure 1 illustrates a vehicle equipped with cameras.

Specifically, as shown in Figure 1, cameras 1–6 are set up such that two cameras are embedded in each of the front and rear bumpers and one camera is embedded in each front directional indicator. *Id.* at 3:36–4:3.

Nissan additionally teaches displaying the positions of other vehicles, the states of obstructions, and the center line. *Id.* at 2:16–18. Figure 3(b), reproduced below, illustrates an exemplary display.

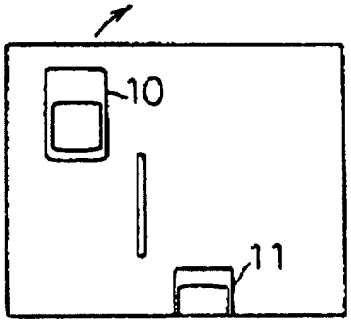

Figure 3(b) is the display during the operation of the right directional indicator.

As illustrated in Figure 3, a plane (road surface) view is depicted showing the center line and neighboring vehicle 11 traveling behind vehicle 10. *Id.* at 4:29–37.

2. Hino

Hino teaches providing a status in the vicinity of an automobile as seen from directly above the automobile. Ex. 1008, 2. Figure 1 of Hino illustrates a bus equipped with cameras. *Id.*

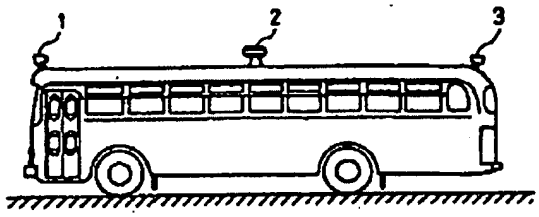

Figure 1 depicts a side-view of a bus equipped with television cameras.

As shown in Figure 1, the bus is equipped with three television cameras mounted on the roof including a television camera with a wide-angle lens positioned at each of the front, center, and rear of the bus. *Id.* Each camera is mounted to display a road surface in the vicinity of the bus. *Id.*

Figure 3 of Hino, reproduced below, illustrates an exemplary display.

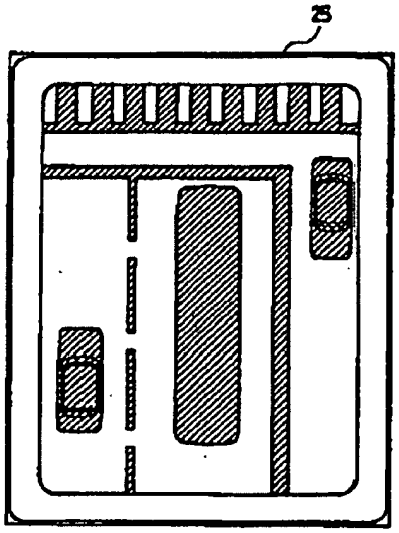

Figure 3 is a view of a display sample of a cathode ray tube disposed at the driver's seat.

As shown in Figure 3, the cathode ray tube displays the road surface in the vicinity of the bus. *Id.* at 3.

3. Lemelson

Lemelson teaches a system and method for assisting the driver of a motor vehicle by displaying warnings of approaching hazards. *See generally* Ex. 1002, Abstract. Lemelson teaches displaying "[a]ctual image data" using a video display (*id.* at 6:46–54), which is received from camera 16 "mounted at the front of the vehicle" (*id.* at 5:31–33). The displayed image "may include highlighting of hazards, special warning images such as flashing lights . . . and other hazard and safety related messages." *Id.* at 6:49–52.

4. Wang and Aishin

We do not provide a summary of Wang or Aishin because Petitioner does not rely on the teachings of Wang or Aishin for either "wherein . . . a

synthesized image is generated" or "wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location," as recited in each of the independent challenged claims. Pet. 28-29. For the reasons discussed below, we are not persuaded by Petitioner's analysis regarding these limitations.

5. The Challenged Independent Claims

Each of the challenged independent claims recites "at least three image capture devices comprising a first image capture device disposed at a driver-side portion[,] . . . a second image capture device disposed at a passenger-side portion[,] . . . [and] a third image capture device disposed at a rear portion of the equipped vehicle." Petitioner contends that these three image capture devices are taught by the following portion of Nissan: "two cameras are embedded in each of the front and rear bumpers, and one in each front directional indicator." Pet. 25–26, 41, 48 (citing Ex. 1004, 4:1–3); *see also id.* at 28 (citing Ex. 1004, 4:15–18, Fig. 4) (contending that the synthesized image is taught by "converting and combining the images from cameras 1 to N into one image.")

Each of the challenged independent claims also recites, "wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle." For the reasons discussed above, we determine that "said synthesized image" means "the image generated by combining the received image data captured by the image capture devices." In other words, the image that is generated by combining the received image data captured by cameras on the sides and rear of the vehicle must approximate a view as would be seen by a virtual camera at a single location exterior the equipped vehicle.

In reliance on the Declaration by Dr. Wolberg, Petitioner contends that Nissan teaches a view from a single location that is directly above a vehicle. Pet. 32 (citing Ex. 1019 ¶¶ 108–109); *see also id.* at 41, 48 ("Petitioner incorporates all support from claim 49 above."). In particular, Dr. Wolberg testifies "it is my opinion that Nissan alone renders obvious this limitation." Ex. 1019 ¶ 108. Dr. Wolberg states that the perspective conversion of Nissan "would be clearly understood by a PHOSITA as being used to obtain a bird's eye view of the vehicle's surroundings." *Id.* Dr. Wolberg also testifies "Figs. 3a-3c of Nissan clearly show images displayed to the driver from a bird's eye view perspective." *Id.*

Although we agree with Dr. Wolberg to the extent that Figure 3(a) displays a view showing the roof of vehicle 10, we disagree with Dr. Wolberg that Figure 3(a) depicts "a view as would be seen by a virtual camera at a single location" (*id.*). Contrary to Dr. Wolberg's testimony, Nissan teaches, "neighboring vehicle 11 is displayed in side view." Ex. 1004, 4:34–35. We, therefore, conclude that Figure 3(a) of Nissan does not illustrate a view as would be seen by a virtual camera at a single location.

Furthermore, neither Petitioner nor Dr. Wolberg explain adequately how the view illustrated in each of Figures 3(b) and 3(c) of Nissan would result from the combination of received image data captured by cameras embedded in the front and rear bumpers and in the front directional indicators illustrated in Figure 1 of Nissan. As Patent Owner notes, "none of the cameras are placed in a location where they could capture the top of another car." PO Resp. 28. We also note that Nissan indicates "the vehicle's position is simultaneously drawn in a diagram." Ex. 1004, 4. In contrast, each of the challenged independent claims requires displaying "said

synthesized image," which is generated by combining the received image data captured by cameras on the sides and rear of the vehicle.

Petitioner, relying on the Declaration of Dr. Wolberg, also contends it would have been obvious to combine Nissan and Hino because "a PHOSITA would look to Hino to improve the depiction of the bird's eye view shown to the driver in Nissan." Pet. 32 (citing Ex. 1019 ¶¶ 110–114). Dr. Wolberg testifies "Nissan is not as ideal an aerial view as would be desired to a driver of the equipped vehicle." Ex. 1019 ¶ 112. In particular, Dr. Wolberg identifies "a distorted view of neighboring vehicle in Fig. 3(a)" of Nissan. *Id.* Dr. Wolberg, states "a PHOSITA would have found it obvious to improve the picture that is shown to the driver of Nissan to depict the ideal aerial view that is shown in Fig. 3 of Hino." *Id.*

As discussed above, Figure 3(a) of Nissan illustrates vehicle 10 in a plane or road surface view whereas "neighboring vehicle 11 is displayed in side view." Ex. 1004, 4:34–35. Dr. Wolberg's testimony that Figure 3(a) of Nissan "clearly shows [an] image[] displayed to the driver from a bird's eye perspective" (Ex. 1019 ¶ 108), but the image "is not as ideal an aerial view as would be desired" (*id.* ¶ 112) does not take into account adequately that neighboring vehicle 11 is displayed in side view. Because Dr. Wolberg's testimony is inconsistent with the Nissan reference, we are not persuaded.

Dr. Wolberg also testifies that "Nissan and Hino show similar views to the driver, and thus are combinable to produce a more robust vision system display." Ex. 1019 ¶ 111. Petitioner, however, points to Nissan's teaching that "two cameras are embedded in each of the front and rear bumpers, and one in each front directional indicator," as rendering obvious the image capture devices recited in the challenged independent claims. Pet.

25–26, 41, 48 (citing Ex. 1004, 4:1–3). Dr. Wolberg testifies, "a PHOSITA would have readily understood that Nissan is not being modified to alter the camera positions or placement of the six cameras in Nissan." Ex. 1019 ¶ 113. Neither Petitioner nor Dr. Wolberg explain adequately how the images captured by Nissan's cameras embedded in bumpers and directional indicators can be mapped to create a plan view of the vicinity of the vehicle, as taught by Hino. Dr. Wolberg provides conclusory statements without explaining persuasively the basis for his view that one of ordinary skill in the art would have known to combine the teachings of Nissan and Hino. *See* 37 C.F.R. § 42.65(a) ("Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.")

We are not persuaded that Petitioner's contentions regarding Lemelson (Pet. 29–31) cure the deficiencies above. Petitioner cites to Lemelson's teaching, e.g., of a reconfigurable display with respect to the following recitation of the independent challenged claims: "wherein said synthesized image is displayed." Petitioner, however, does not rely on Lemelson's teachings for either "wherein . . . a synthesized image is generated" or "wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location," as recited in each of the independent challenged claims. Pet. 28-29. Petitioner also does not rely on the teachings of Wang or Aishin for these recitations. *Id.* We, therefore, also are not persuaded that Petitioner's contentions regarding Wang or Aishin cure the deficiencies noted above.

C. Other Asserted Grounds

Petitioner also asserts other grounds of unpatentability contending that the challenged dependent claims of the '724 Patent are unpatentable, under

35 U.S.C. §103. Pet. 32–39, 42–45, 48–57. Each of these other claims depends directly from one of the challenged independent claims. For the reasons given, we are not persuaded that Petitioner has met its burden with respect to the challenged independent claims. We, therefore, determine that Petitioner has not established a reasonable likelihood that it would prevail with respect to the challenged dependent claims.

III. ORDER

For the reasons given, it is

ORDERED that the Petition is denied and no *inter partes* review is instituted.

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Paper 7
Entered: May 13, 2015

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

VALEO NORTH AMERICA, INC., VALEO S.A., VALEO GMBH, VALEO SCHALTER UND SENSOREN GMBH, AND CONNAUGHT ELECTRONICS LTD.,
Petitioner,

v.

MAGNA ELECTRONICS, INC.,
Patent Owner.

Case IPR2015-00252
U.S. Patent No. 8,643,724 B2

Before RICHARD E. RICE, JAMES A. TARTAL, and BARBARA A. PARVIS, *Administrative Patent Judges.*

PARVIS, *Administrative Patent Judge.*

DECISION
Denying Institution of *Inter Partes* Review
37 C.F.R. § 42.108

I. INTRODUCTION

A. Background

Valeo North America, Inc., Valeo S.A., Valeo GmbH, Valeo Schalter Und Sensoren GmbH, and Connaught Electronics Ltd. ("Petitioner") filed a

Petition (Paper 1, "Pet.") requesting an *inter partes* review of claims 1–48 ("challenged claims") of U.S. Patent No. 8,643,724 B2 (Exhibit 1001, "the '724 Patent"). Magna Electronics, Inc. ("Patent Owner") filed a Preliminary Response. Paper 6 ("Prelim. Resp."). We have jurisdiction under 35 U.S.C. § 314, which provides that an *inter partes* review may not be instituted unless "the information presented in the petition . . . and any [preliminary] response . . . shows that there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition." 35 U.S.C. § 314(a).

Based on our review of the record, we determine that Petitioner has not established a reasonable likelihood that it would prevail with respect to any of the challenged claims.

B. Related Proceedings

Petitioner and Patent Owner identify, as related proceedings, a district court case involving alleged infringement of the '724 Patent, which is *Magna Electronics Inc. v. Valeo, Inc.*, No. 2:14-cv-10540 (E.D. Mich.). Pet. 4; *see* Magna Electronics, Inc.'s Mandatory Notices Pursuant to 37 C.F.R. § 42.8 ("Patent Owner Notice," Paper 4).

C. The '724 Patent

The '724 Patent relates to multi-camera vision systems for vehicles. *See generally* Ex. 1001, Abstract. According to the '724 Patent, a long-felt need in the art of vehicle rearview vision systems has been to eliminate exterior rearview mirrors by using image capture devices, such as cameras, in combination with dashboard displays. *Id.* at 1:43–46. Prior art camera-based systems, however, had not obtained commercial acceptance because they presented too much information in a confusing manner. *Id.* at 1:60–64.

To address these issues, the '724 Patent describes a rearview vision system having two side image capture devices positioned, respectively, on opposite sides of the vehicle and a center image capture device disposed at a rear portion of the vehicle. *Id.* at 5:53–58. The '724 Patent describes techniques for synthesizing images captured by these image capture devices to form a view as would be seen from a camera at a single location, and that is displayed to the driver. *See e.g., id.* at 3:12–25.

Figure 3, reproduced below, depicts a display according to the invention.

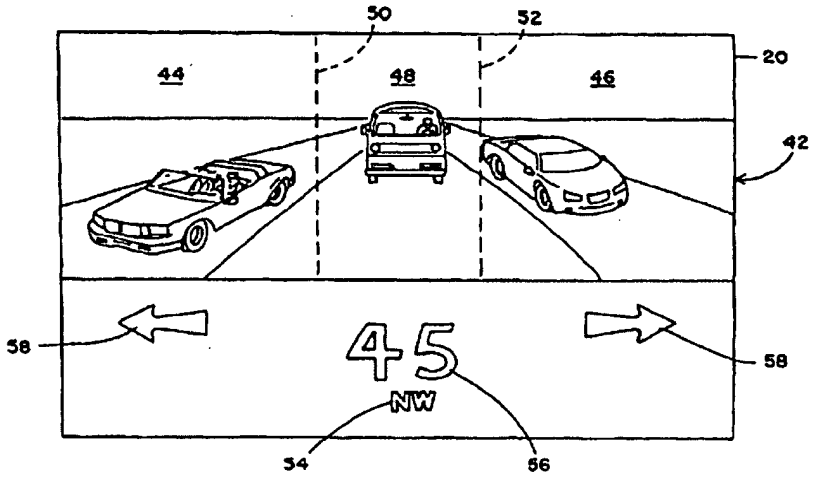

FIG. 3

Figure 3 illustrates image display device 20 displaying composite image 42.

As shown in Figure 3, composite image 42 is made up of left image portion 44, right image portion 46, and center image portion 48. *Id.* at 7:44–46. The image portions at boundaries 50 and 52 are continuous such that composite image 42 is a seamless panoramic view rearwardly of the vehicle. *Id.* at 7:55–58. Composite image 42 provides a clear image that avoids

confusion and simplifies the task of extracting information from the multiple image portions. *Id.* at 7:64–67.

D. *Illustrative Claim*

Claim 1 is the only independent claim challenged by Petitioner. We do not address the additional prior art or grounds of unpatentability Petitioner asserts against dependent claims 2–48 because Petitioner has not established a reasonable likelihood that it would prevail with respect to claim 1, from which each of claims 2–48 depends, directly or indirectly. Claim 1 is illustrative and is reproduced below:

> 1. A multi-camera vision system for a vehicle, said vehicular multi-camera vision system comprising:
>
> at least three image capture devices disposed at a vehicle equipped with said vehicular multi-camera vision system;
>
> said at least three image capture devices comprising a first image capture device disposed at a driver-side portion of the equipped vehicle at a first location;
>
> said at least three image capture devices comprising a second image capture device disposed at a passenger-side portion of the equipped vehicle at a second location;
>
> said at least three image capture devices comprising a third image capture device disposed at a rear portion of the equipped vehicle at a third location;
>
> wherein said first image capture device has a first field of view exterior of the equipped vehicle;
>
> wherein said second image capture device has a second field of view exterior of the equipped vehicle;
>
> wherein said third image capture device has a third field of view exterior of the equipped vehicle;
>
> wherein said first field of view of said first image capture device overlaps with said third field of view of said third image capture device defining a first overlap zone;
>
> wherein said second field of view of said second image capture device overlaps with said third field of view of said third image capture device defining a second overlap zone;

wherein said first image capture device captures first image data;

wherein said second image capture device captures second image data;

wherein said third image capture device captures third image data;

an image processor;

wherein first image data captured by said first image capture device is received at said image processor via at least one of an analog data stream and a digital data stream;

wherein second image data captured by said second image capture device is received at said image processor via at least one of an analog data stream and a digital data stream;

wherein third image data captured by said third image capture device is received at said image processor via at least one of an analog data stream and a digital data stream;

wherein, responsive to processing by said image processor of received image data, a synthesized image is generated without duplication of objects present in said first overlap zone and in said second overlap zone and wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle; and

wherein said synthesized image is displayed by a single display screen of a reconfigurable display device that is viewable by a driver of the equipped vehicle when normally operating the equipped vehicle.

E. *The Asserted Prior Art*

Petitioner relies upon the prior art references below in its challenge of independent claim 1. Pet. 10.

Reference	Patent No. or Publication No.	Issued, Filed, or Published Date	Exhibit No.
Lemelson	U.S. Patent No. 6,553,130 B1	Filed: June 28, 1996 Issued: Apr. 22, 2003	1002

Nissan	Japanese Publication No. JP H3-99952	Published: Apr. 25, 1991	1003 (1004)[1]
Hino	Japanese Publication No. 62-16073	Published: Apr. 10, 1987	1007 (1008)

F. *The Asserted Grounds of Unpatentability*

Petitioner challenges independent claim 1 of the '724 Patent, under 35 U.S.C. § 103(a), as obvious over the combination of Nissan, Hino, and Lemelson. Pet. 10. In support of this ground, Petitioner presents a Declaration by Dr. George Wolberg (Ex. 1019) and a Declaration by Dr. Ralph Wilhelm (Ex. 1020). Petitioner also asserts grounds of unpatentability for dependent claims 2–48. Pet. 10.

II. ANALYSIS

A. Claim Construction

1. Legal Standard

In an *inter partes* review, claim terms in an unexpired patent are interpreted according to their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.300(b); *see also In re Cuozzo Speed Techs., LLC.*, 778 F.3d 1271, 1281–1282 (Fed. Cir. 2015) ("Congress implicitly adopted the broadest reasonable interpretation standard in enacting the AIA," and "the standard was properly adopted by [United States Patent and Trademark Office ('USPTO')] regulation."). Under the broadest reasonable construction standard, and absent any special

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definitions, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007) (quoting *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312 (Fed. Cir. 2005) (en banc)).

2. "said synthesized image"

The term "said synthesized image" is recited in independent claim 1. Neither party proposes a construction for that term. Patent Owner, however, contends that Nissan and Hino are insufficient to teach "wherein *said synthesized image* approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle," as recited in claim 1. Prelim. Resp. 31. To evaluate Patent Owner's contention, we determine the broadest reasonable interpretation of "said synthesized image."

The antecedent basis for "said synthesized image" is within the following phrase: "wherein, responsive to processing by said image processor of received image data, *a synthesized image* is generated" (emphasis added). Accordingly, "said synthesized image" is generated by synthesizing the received image data captured by the image capture devices.

The '724 Patent Specification does not define "synthesized." A dictionary definition is useful in ascertaining the way in which one of ordinary skill in the art would use the term. *Starhome GmbH v. AT&T Mobility LLC*, 743 F.3d 849, 856–57 (Fed. Cir. 2014). The Chambers 21st Century Dictionary defines "synthesize" as "*to combine* (simple parts) to form (a complex whole)." *Chambers 21st Century Dictionary* (2001) *available at* http://search.credoreference.com/content/entry/chambdict

/synthesize_or_synthesise/0 (retrieved on April 22, 2015) (Ex. 3001) (emphasis added).

The dictionary definition is consistent with the use of "synthesize" in the '724 Patent Specification. For instance, the '724 Patent Specification states, "[r]earview vision system 12 additionally includes [ ] image processor 18 for receiving data signals from image capture devices 14, 16 and *synthesizing, from the data signals*, [ ] composite image 42 which is displayed on [ ] display 20." Ex. 1001, 5:57–62 (emphasis added). The '724 Patent Specification more particularly describes that the composite image is "*made up of*" image portions, and "[e]ach image portion 44–48 is reversed from the image as captured by the respective image capture device." *Id.* at 7:44–49 (emphasis added). Additionally, the '724 Patent Specification indicates that the synthesized image is generated by a "[c]ombined image generator." *Id.* at 11:34–35; *see also id.* at 12:29–31 ("[m]erging of multiple image portions would require additional combined image generators.")

Upon review, we determine that construing "said synthesized image" as "the image generated by combining the received image data captured by the image capture devices" is the broadest reasonable interpretation consistent with the '724 Patent Specification.

B. Asserted Obviousness of Claim 1 over Nissan, Hino, and Lemelson

Petitioner contends that independent claim 1 of the '724 Patent is unpatentable as obvious over the combination of Nissan, Hino, and Lemelson. Pet. 25–32. In light of the arguments and evidence submitted, Petitioner has not established a reasonable likelihood that it would prevail

with respect to its contention that claim 1 is unpatentable as obvious over the combination of Nissan, Hino, and Lemelson.

1. Nissan

Nissan teaches a device for displaying information about a vehicle's surroundings to the driver by using cameras. Ex. 1004, 2:16–20. Figure 1 of Nissan, reproduced below, illustrates placement of the cameras.

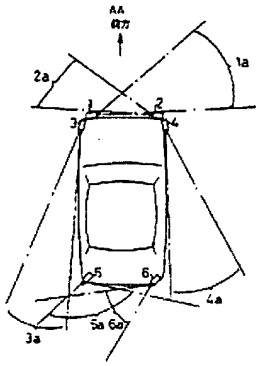

Figure 1 illustrates a vehicle equipped with cameras.

Specifically, as shown in Figure 1, cameras 1–6 are set up such that two cameras are embedded in each of the front and rear bumpers and one camera is embedded in each front directional indicator. *Id.* at 3:36–4:3.

Nissan additionally teaches displaying the positions of other vehicles, the states of obstructions, and the center line. *Id.* at 2:16–18. Figure 3(b), reproduced below, illustrates an exemplary display.

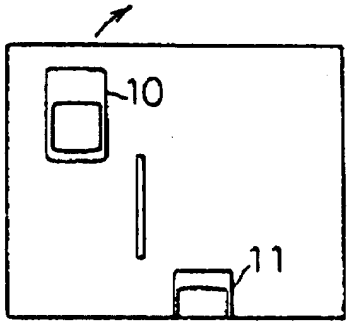

Figure 3(b) is the display during the operation of the right directional indicator.

As illustrated in Figure 3, a plane (road surface) view is depicted showing the center line and neighboring vehicle 11 traveling behind vehicle 10. *Id.* at 4:29–37.

2. Hino

Hino teaches providing a status in the vicinity of an automobile as seen from directly above the automobile. Ex. 1008, 2. Figure 1 of Hino illustrates a bus equipped with cameras. *Id.*

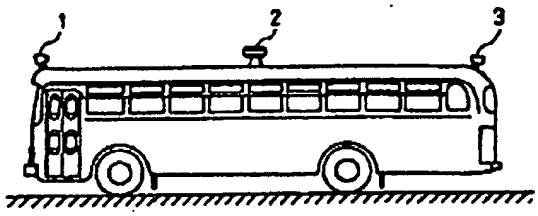

Figure 1 depicts a side-view of a bus equipped with television cameras.

As shown in Figure 1, the bus is equipped with three television cameras mounted on the roof including a television camera with a wide-angle lens positioned at each of the front, center, and rear of the bus. *Id.*

Each camera is mounted to display a road surface in the vicinity of the bus. *Id.*

Figure 3 of Hino, reproduced below, illustrates an exemplary display.

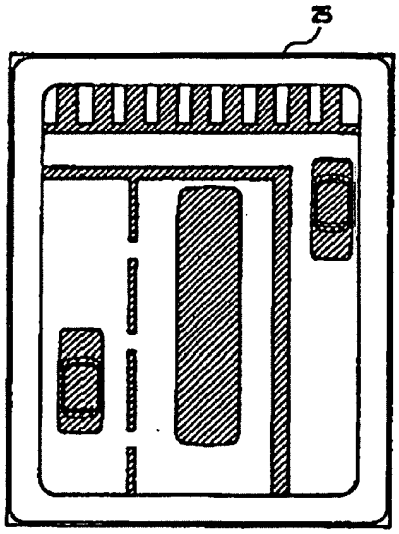

Figure 3 is a view of a display sample of a cathode ray tube disposed at the driver's seat.

As shown in Figure 3, the cathode ray tube displays the road surface in the vicinity of the bus. *Id.* at 3.

3. Lemelson

Lemelson teaches a system and method for assisting the driver of a motor vehicle by displaying warnings of approaching hazards. *See generally* Ex. 1002, Abstract. Lemelson teaches displaying "[a]ctual image data" using a video display (*id.* at 6:46–54), which is received from camera 16 "mounted at the front of the vehicle" (*id.* at 5:31–33). The displayed image "may include highlighting of hazards, special warning images such as flashing lights . . . and other hazard and safety related messages." *Id.* at 6:49–52.

4. Claim 1

Claim 1 recites "at least three image capture devices comprising a first image capture device disposed at a driver-side portion[,] . . . a second image capture device disposed at a passenger-side portion[,] . . . [and] a third image capture device disposed at a rear portion of the equipped vehicle." Petitioner contends that these three image capture devices are taught by the following portion of Nissan: "two cameras are embedded in each of the front and rear bumpers, and one in each front directional indicator." Pet. 26–27 (citing Ex. 1004, 4:1–3); *see also id.* at 29 (citing Ex. 1004, 4:15–18, Fig. 4) (contending that the synthesized image is taught by "converting and combining the images from cameras 1 to N into one image.")

Claim 1 also recites, "wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location exterior of the equipped vehicle." For the reasons discussed above, we determine that "said synthesized image" means "the image generated by combining the received image data captured by the image capture devices." In other words, the image that is generated by combining the received image data captured by cameras on the sides and rear of the vehicle must approximate a view as would be seen by a virtual camera at a single location exterior the equipped vehicle.

In reliance on the Declaration by Dr. Wolberg, Petitioner contends that Nissan teaches an image produced from a single virtual location that is directly above a vehicle. Pet. 31 (citing Ex. 1019 ¶¶ 108–109). In particular, Dr. Wolberg testifies "it is my opinion that Nissan alone renders obvious this limitation." Ex. 1019 ¶ 108. Dr. Wolberg states that the perspective conversion of Nissan "would be clearly understood by a

PHOSITA as being used to obtain a bird's eye view of the vehicle's surroundings." *Id.* Dr. Wolberg also testifies "Figs. 3a-3c of Nissan clearly show images displayed to the driver from a bird's eye view perspective." *Id.*

Although we agree with Dr. Wolberg to the extent that Figure 3(a) displays a view showing the roof of vehicle 10, we disagree with Dr. Wolberg that Figure 3(a) depicts "a view as would be seen by a virtual camera at a single location" (*id.*). Contrary to Dr. Wolberg's testimony, Nissan teaches, "neighboring vehicle 11 is displayed in side view." Ex. 1004, 4:34–35. We, therefore, conclude that Figure 3(a) of Nissan does not illustrate a view as would be seen by a virtual camera at a single location.

Furthermore, neither Petitioner nor Dr. Wolberg explain adequately how the view illustrated in each of Figures 3(b) and 3(c) of Nissan would result from the combination of received image data captured by cameras embedded in the front and rear bumpers and in the front directional indicators illustrated in Figure 1 of Nissan. As Patent Owner notes, "none of the cameras are placed in a location where they could capture the top of another car." PO Resp. 32. We also note that Nissan indicates "the vehicle's position is simultaneously drawn in a diagram." Ex. 1004, 4. In contrast, claim 1 requires displaying "said synthesized image," which is generated by combining the received image data captured by cameras on the sides and rear of the vehicle.

Petitioner, relying on the Declaration of Dr. Wolberg, also contends "it would have been obvious to combine Nissan and Hino to achieve an ideal view shown to the driver from the perspective of a virtual camera at a single location directly above the vehicle, looking downward." Pet. 32 (citing Ex. 1019 ¶¶ 110–114). Dr. Wolberg testifies "Nissan is not as ideal an aerial

view as would be desired to a driver of the equipped vehicle." Ex. 1019 ¶ 112. In particular, Dr. Wolberg identifies "a distorted view of neighboring vehicle in Fig. 3(a)" of Nissan. *Id.* Dr. Wolberg, states "a PHOSITA would have found it obvious to improve the picture that is shown to the driver of Nissan to depict the ideal aerial view that is shown in Fig. 3 of Hino." *Id.*

As discussed above, Figure 3(a) of Nissan illustrates vehicle 10 in a plane or road surface view whereas "neighboring vehicle 11 is displayed in side view." Ex. 1004, 4:34–35. Dr. Wolberg's testimony that Figure 3(a) of Nissan "clearly shows [an] image[] displayed to the driver from a bird's eye perspective" (Ex. 1019 ¶ 108), but the image "is not as ideal an aerial view as would be desired" (*id.* ¶ 112) does not take into account adequately that neighboring vehicle 11 is displayed in side view. Because Dr. Wolberg's testimony is inconsistent with the Nissan reference, we are not persuaded.

Dr. Wolberg also testifies that "Nissan and Hino show similar views to the driver, and thus are combinable to produce a more robust vision system display." Ex. 1019 ¶ 111. Petitioner, however, points to Nissan's teaching that "two cameras are embedded in each of the front and rear bumpers, and one in each front directional indicator," as rendering obvious the image capture devices recited in claim 1. Pet. 26–27 (citing Ex. 1004, 4:1–3). Dr. Wolberg testifies, "a PHOSITA would have readily understood that Nissan is not being modified to alter the camera positions or placement of the six cameras in Nissan." Ex. 1019 ¶ 113. Neither Petitioner nor Dr. Wolberg explain adequately how the images captured by Nissan's cameras embedded in bumpers and directional indicators can be mapped to create a plan view of the vicinity of the vehicle, as taught by Hino. Dr.

Wolberg provides conclusory statements without explaining persuasively the basis for his view that one of ordinary skill in the art would have known to combine the teachings of Nissan and Hino. *See* 37 C.F.R. § 42.65(a) ("Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.")

We are not persuaded that Petitioner's contentions regarding Lemelson (Pet. 30–31) cure the deficiencies above. Petitioner cites to Lemelson's teaching, e.g., of a reconfigurable display with respect to the following recitation of claim 1: "wherein said synthesized image is displayed." Petitioner, however, does not rely on Lemelson's teachings for either "wherein . . . a synthesized image is generated" or "wherein said synthesized image approximates a view as would be seen by a virtual camera at a single location," as recited in claim 1. Pet. 29.

C. Other Asserted Grounds

Petitioner also asserts other grounds of unpatentability contending that claims 2-48 of the '724 Patent are unpatentable, under 35 U.S.C. §103. Pet. 32–59. Each of these other claims depends, directly or indirectly, from independent claim 1. Additionally, each of the other grounds asserted by Petitioner is based on claim 1 being obvious over the combination of Nissan, Hino, and Lemelson. *Id.* For the reasons given, we are not persuaded that Petitioner has met its burden with respect to independent claim 1. We, therefore, determine that Petitioner has not established a reasonable likelihood that it would prevail with respect to the dependent claims.

III. ORDER

For the reasons given, it is

ORDERED that the Petition is denied and no *inter partes* review is instituted.

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