

|         |             |       |                |                     |
|---------|-------------|-------|----------------|---------------------|
| BER     | FILING DATE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
| 175,685 | 10/20/98    | 348   | 2713           | F97.13-CIP2         |

WIN L. ADAIR, CASTLE PINES VILLAGE, CO; JEFFREY L. ADAIR,  
 HIGHLANDS RANCH, CO; RANDALL S. ADAIR, DENVER, CO.

\*\*CONTINUING DOMESTIC DATA\*\*\*\*\*  
 VERIFIED THIS APPLN IS A CIP OF 08/944,322 10/06/97

\*\*371 (NAT'L STAGE) DATA\*\*\*\*\*  
 VERIFIED

\*\*FOREIGN APPLICATIONS\*\*\*\*\*  
 VERIFIED

FOREIGN FILING LICENSE GRANTED 10/29/98

\*\*\*\*\* SMALL ENTITY \*\*\*\*\*

|   |   |                           |                         |                      |                            |
|---|---|---------------------------|-------------------------|----------------------|----------------------------|
| Foreign Priority claimed<br>35 USC 119 (a-d) conditions met           | <input type="checkbox"/> yes <input type="checkbox"/> no<br><input type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> Met after Allowance | STATE OR<br>COUNTRY<br>CO | SHEETS<br>DRAWING<br>11 | TOTAL<br>CLAIMS<br>7 | INDEPENDENT<br>CLAIMS<br>2 |
| Verified and Acknowledged<br>Examiner's Initials _____ Initials _____ |   |                           |                         |                      |                            |

ADDRESS  
 BRENT P JOHNSON  
 FIELDS & JOHNSON  
 SUITE 5600  
 8480 EAST ORCHARD ROAD  
 ENGLEWOOD CO 80111

TITLE  
 REDUCED AREA IMAGING DEVICES

FILING FEE  
 RECEIVED

\$395

FEES: Authority has been given in Paper  
 No. \_\_\_\_\_ to charge/credit DEPOSIT ACCOUNT  
 NO. \_\_\_\_\_ for the following:

|                          |                                     |
|--------------------------|-------------------------------------|
| <input type="checkbox"/> | 1.15 Fees (Filing)                  |
| <input type="checkbox"/> | 1.17 Fees (Processing Ext. of time) |
| <input type="checkbox"/> | 1.18 Fees (Issue)                   |
| <input type="checkbox"/> | Other _____                         |
| <input type="checkbox"/> | Credit _____                        |

Samsung Exhibit 1073

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

PTO/SB/05 (2/98)  
Approved for use through 09/30/2000. OMB 0651-0032  
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 displays a valid OMB control number.

# UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No. F97.13 CIP2  
First Inventor or Application Identifier Edwin L. Adair, et al.  
Title Reduced Area Imaging Devices  
Express Mail Label No. EL146014919US

## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents  
Box Patent Application  
Washington, DC 20231

1. ☒ \* Fee Transmittal Form (e.g., PTO/SB/17)  
(Submit an original and a duplicate for fee processing)
2. ☒ Specification [Total Pages 31]  
(preferred arrangement set forth below)
  - Descriptive title of the invention
  - Cross References to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to Microfiche Appendix
  - Background of the invention
  - Brief Summary of the invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claim(s)
  - Abstract of the Disclosure
3. ☒ Drawing(s) (35 U.S.C. 113) [Total Sheets 11]
4. Oath or Declaration [Total Pages 3]
  - a. ☒ Newly executed (original or copy)
  - b. ☐ Copy from a prior application (37 C.F.R. § 1.63(d))  
(for continuation/divisional with Box 17 completed)  
(Note Box 5 below)
  - i. ☐ DELETION OF INVENTOR(S)  
Signed statement attached deleting  
inventor(s) named in the prior application,  
see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference (useable if Box 4b is checked)  
The entire disclosure of the prior application, from which a  
copy of the oath or declaration is supplied under Box 4b, is  
considered to be part of the disclosure of the accompanying  
application and is hereby incorporated by reference therein.

6. ☐ Microfiche Computer Program (Appendix)
7. Nucleotide and/or Amino Acid Sequence Submission  
(if applicable, all necessary)
  - a. ☐ Computer Readable Copy
  - b. ☐ Paper Copy (identical to computer copy)
  - c. ☐ Statement verifying identity of above copies

## ACCOMPANYING APPLICATION PARTS

8. ☐ Assignment Papers (cover sheet & document(s))
9. ☐ 37 C.F.R. § 3.73(b) Statement  
(when there is an assignee) ☒ Power of Attorney
10. ☐ English Translation Document (if applicable)
11. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☒ Return Receipt Postcard (MPEP 503)  
(Should be specifically itemized)
14. ☒ \* Small Entity Statement(s) ☐ Statement filed in prior application,  
(PTO/SB/09-12) Status still proper and desired
15. ☐ Certified Copy of Priority Document(s)  
(if foreign priority is claimed)
16. ☐ Other: Declaration Under 37 CFR 1.102  
Petition to Make Special (1.102)

\* NOTE FOR ITEMS 1 & 14: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY  
FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT  
IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

17. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:

☐ Continuation ☐ Divisional ☒ Continuation-in-part (CIP) of prior application No: 08 / 944,322  
Prior application Information: Examiner A. Rao Group / Art Unit: 2713

## 18. CORRESPONDENCE ADDRESS

☐ Customer Number or Bar Code Label (Insert Customer No. or Attach bar code label here) or ☒ Correspondence address below

|         |   |           |                     |          |                     |
|---------|---|-----------|---------------------|----------|---------------------|
| Name    | <u>Brent P. Johnson</u>                   |           |                     |          |                     |
|         | <u>Fields &amp; Johnson, P.C.</u>         |           |                     |          |                     |
| Address | <u>8480 East Orchard Road, Suite 5600</u> |           |                     |          |                     |
| City    | <u>Englewood</u>                          | State     | <u>CO</u>           | Zip Code | <u>80111</u>        |
| Country | <u>U.S.A.</u>                             | Telephone | <u>303-689-9100</u> | Fax      | <u>303-689-9250</u> |

|                   |                         |                                   |                 |
|-------------------|-------------------------|-----------------------------------|-----------------|
| Name (Print/Type) | <u>Brent P. Johnson</u> | Registration No. (Attorney/Agent) | <u>38,031</u>   |
| Signature         | <u>B.P. Johnson</u>     | Date                              | <u>10/20/98</u> |

Burden Hour Statement: This form is estimated to take 0.2 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: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

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.

**FEE TRANSMITTAL**

Patent fees are subject to annual revision on October 1.

These are the fees effective October 1, 1997.

Small Entity payments must be supported by a small entity statement,  
otherwise large entity fees must be paid. See Forms PTO/SB/09-12.  
See 37 C.F.R. §§ 1.27 and 1.28.

TOTAL AMOUNT OF PAYMENT (\$) 395.00

**Complete if Known**

|                      |                        |
|----------------------|------------------------|
| Application Number   |                        |
| Filing Date          |                        |
| First Named Inventor | Edwin L. Adair, et al. |
| Examiner Name        |                        |
| Group / Art Unit     |                        |
| Attorney Docket No.  | F97.13 CIP2            |

**METHOD OF PAYMENT (check one)**

- 1.
- ☒
- The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

|                        |                        |
|------------------------|------------------------|
| Deposit Account Number | 06-0778                |
| Deposit Account Name   | Fields & Johnson, P.C. |

☒ Charge Any Additional Fee Required Under 37 C.F.R. §§ 1.16 and 1.17 ☐ Charge the Issue Fee Set in 37 C.F.R. § 1.16 at the Mailing of the Notice of Allowance

- 2.
- ☒
- Payment Enclosed:
- 
- ☒
- Check
- ☐
- Money Order
- ☐
- Other

**FEE CALCULATION****1. BASIC FILING FEE**

| Large Entity Fee Code (\$) | Small Entity Fee Code (\$) | Fee Description        | Fee Paid   |
|----------------------------|----------------------------|------------------------|------------|
| 101 790                    | 201 395                    | Utility filing fee     | 395        |
| 106 330                    | 206 165                    | Design filing fee      |            |
| 107 540                    | 207 270                    | Plant filing fee       |            |
| 108 790                    | 208 395                    | Reissue filing fee     |            |
| 114 150                    | 214 75                     | Provisional filing fee |            |
| <b>SUBTOTAL (1)</b>        |                            |                        | <b>395</b> |

**2. EXTRA CLAIM FEES**

| Total Claims              | Extra Claims | Fee from below | Fee Paid |
|---------------------------|--------------|----------------|----------|
| Independent Claims        | 7 - 20** = 0 | X 11 = 0       |          |
| Multiple Dependent Claims | 2 - 3** = 0  | X 41 = 0       |          |

\*\*or number previously paid, if greater; For Reissues, see below

| Large Entity Fee Code (\$) | Small Entity Fee Code (\$) | Fee Description  |
|----------------------------|----------------------------|--|
| 103 22                     | 203 11                     | Claims in excess of 20                                     |
| 102 82                     | 202 41                     | Independent claims in excess of 3                          |
| 104 270                    | 204 135                    | Multiple dependent claim, if not paid                      |
| 109 82                     | 209 41                     | ** Reissue independent claims over original patent         |
| 110 22                     | 210 11                     | ** Reissue claims in excess of 20 and over original patent |

**SUBTOTAL (2)** (\$) 0**FEE CALCULATION (continued)****3. ADDITIONAL FEES**

| Large Entity Fee Code (\$) | Small Entity Fee Code (\$) | Fee Description  | Fee Paid |
|----------------------------|----------------------------|--|----------|
| 105 130                    | 205 65                     | Surcharge - late filing fee or oath  |          |
| 127 50                     | 227 25                     | Surcharge - late provisional filing fee or cover sheet                     |          |
| 139 130                    | 139 130                    | Non-English specification  |          |
| 147 2,520                  | 147 2,520                  | For filing a request for reexamination                                     |          |
| 112 920*                   | 112 920*                   | Requesting publication of SIR prior to Examiner action                     |          |
| 113 1,840*                 | 113 1,840*                 | Requesting publication of SIR after Examiner action                        |          |
| 115 110                    | 215 55                     | Extension for reply within first month                                     |          |
| 116 400                    | 216 200                    | Extension for reply within second month                                    |          |
| 117 950                    | 217 475                    | Extension for reply within third month                                     |          |
| 118 1,510                  | 218 755                    | Extension for reply within fourth month                                    |          |
| 128 2,080                  | 228 1,030                  | Extension for reply within fifth month                                     |          |
| 119 310                    | 219 155                    | Notice of Appeal   |          |
| 120 310                    | 220 155                    | Filing a brief in support of an appeal                                     |          |
| 121 270                    | 221 135                    | Request for oral hearing   |          |
| 138 1,510                  | 138 1,510                  | Petition to institute a public use proceeding                              |          |
| 140 110                    | 240 55                     | Petition to revive - unavoidable   |          |
| 141 1,320                  | 241 660                    | Petition to revive - unintentional   |          |
| 142 1,320                  | 242 660                    | Utility issue fee (or reissue)   |          |
| 143 450                    | 243 225                    | Design issue fee   |          |
| 144 670                    | 244 335                    | Plant issue fee  |          |
| 122 130                    | 122 130                    | Petitions to the Commissioner  |          |
| 123 50                     | 123 50                     | Petitions related to provisional applications                              |          |
| 126 240                    | 126 240                    | Submission of Information Disclosure Stmt                                  |          |
| 581 40                     | 581 40                     | Recording each patent assignment per property (times number of properties) |          |
| 146 790                    | 246 395                    | Filing a submission after final rejection (37 CFR 1.129(a))                |          |
| 149 790                    | 249 395                    | For each additional invention to be examined (37 CFR 1.129(b))             |          |

Other fee (specify) \_\_\_\_\_

Other fee (specify) \_\_\_\_\_

\* Reduced by Basic Filing Fee Paid

**SUBTOTAL (3)** (\$) 0**SUBMITTED BY**

Typed or Printed Name Brent P. Johnson

Signature

Date 10/20/98

**Complete (if applicable)**

Reg. Number 38,031

Deposit Account User ID 06-0778

Burden Hour Statement: This form is estimated to take 0.2 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: Assistant Commissioner for Patents, Washington, DC 20231.

10/20/98  
1512 U.S. PTO

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Continuation-in-Part Application of )  
)  
Edwin L. Adair, Jeffrey L. Adair, )  
Randall S. Adair )  
)  
Corresponding to )  
U.S. Serial No. 08/944,322 )  
Filed: October 6, 1997 )  
)  
For: "Reduced Area Imaging Devices" )

"Express Mail" mailing label number EL146014919US

Date of Deposit: October 20, 1997

I hereby certify that the following:

- Patent application
- 11 sheets of formal drawings
- Declaration and Power of Attorney
- Declaration Under 37 CFR 1.102
- Petition to Make Special Under 37 CFR 1.102
- Verified Statement for Small Entity
- Patent Application Transmittal form
- 1 original and 1 copy of Fee Transmittal form and Fee Determination Record form
- Check for \$ 395.00 for the filing fees
- Return postcard

are being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and are addressed to the BOX PATENT APPLICATION, Assistant Commissioner for Patents, Washington, D.C. 20231 .

Katherine L. Goncalves  
Katherine L. Goncalves  
8480 East Orchard Road, Suite 5600  
Englewood, CO 80111  
(303) 689-9100

Date: 10/20/98

**REDUCED AREA IMAGING DEVICES**

This application is a continuation-in-part of U.S. Serial No. 08/944,322, filed October 6, 1997, and entitled "Reduced Area Imaging Devices Incorporated Within Surgical Instruments."

**5     Technical Field**

This invention relates to solid state image sensors and associated electronics, and more particularly, to solid state image sensors which are configured to be of a minimum size.

**Background Art**

10           In recent years, endoscopic surgery has become the accepted standard for conducting many types of surgical procedures, both in the medical and dental arenas. The availability of imaging devices enabling a surgeon or dentist to view a particular surgical area through a small diameter endoscope which is introduced into small cavities or openings in  
15           the body results in much less patient trauma as well as many other advantages.

          In many hospitals, the rod lens endoscope is still used in endoscopic surgery. The rod lens endoscope includes a very precise group of lenses in an elongate and rigid tube which are able to accurately transmit an image to  
20           a remote camera in line with the lens group. The rod lens endoscope, because of its cost of manufacture, failure rate, and requirement to be housed within a rigid and straight housing, is being increasingly replaced by solid state imaging technology which enables the image sensor to be placed at the distal tip of the investigating device. The three most common  
25           solid state image sensors include charged coupled devices (CCD), charge injection devices (CID) and photo diode arrays (PDA). In the mid-1980s,



complementary metal oxide semiconductors (CMOS) were developed for industrial use. CMOS imaging devices offer improved functionality and simplified system interfacing. Furthermore, many CMOS imagers can be manufactured at a fraction of the cost of other solid state imaging technologies.

One particular advance in CMOS technology has been in the active pixel-type CMOS imagers which consist of randomly accessible pixels with an amplifier at each pixel site. One advantage of active pixel-type imagers is that the amplifier placement results in lower noise levels than CCDs or other solid state imagers. Another major advantage is that these CMOS imagers can be mass produced on standard semiconductor production lines. One particularly notable advance in the area of CMOS imagers including active pixel-type arrays is the CMOS imager described in U.S. Patent No. 5,471,515 to Fossum, et al. This CMOS imager can incorporate a number of other different electronic controls that are usually found on multiple circuit boards of much larger size. For example, timing circuits, and special functions such as zoom and anti-jitter controls can be placed on the same circuit board containing the CMOS pixel array without significantly increasing the overall size of the host circuit board. Furthermore, this particular CMOS imager requires 100 times less power than a CCD-type imager. In short, the CMOS imager disclosed in Fossum, et al. has enabled the development of a "camera on a chip."

Passive pixel-type CMOS imagers have also been improved so that they too can be used in an imaging device which qualifies as a "camera on a chip." In short, the major difference between passive and active CMOS pixel arrays is that a passive pixel-type imager does not perform signal amplification at each pixel site. One example of a manufacturer which has

developed a passive pixel array with performance nearly equal to known active pixel devices and being compatible with the read out circuitry disclosed in the U.S. Patent No. 5,471,515 is VLSI Vision, Ltd., 1190 Saratoga Avenue, Suite 180, San Jose, California 95129. A further  
5 description of this passive pixel device may be found in co-pending application, Serial No. 08/976,976, entitled "Reduced Area Imaging Devices Incorporated Within Surgical Instruments," and is hereby incorporated by reference.

In addition to the active pixel-type CMOS imager which is disclosed  
10 in U.S. Patent No. 5,471,515, there have been developments in the industry for other solid state imagers which have resulted in the ability to have a "camera on a chip." For example, Suni Microsystems, Inc. of Mountain View, California, has developed a CCD/CMOS hybrid which combines the high quality image processing of CCDs with standard CMOS circuitry  
15 construction. In short, Suni Microsystems, Inc. has modified the standard CMOS and CCD manufacturing processes to create a hybrid process providing CCD components with their own substrate which is separate from the P well and N well substrates used by the CMOS components. Accordingly, the CCD and CMOS components of the hybrid may reside on  
20 different regions of the same chip or wafer. Additionally, this hybrid is able to run on a low power source (5 volts) which is normally not possible on standard CCD imagers which require 10 to 30 volt power supplies. A brief explanation of this CCD/CMOS hybrid can be found in the article entitled "Startup Suni Bets on Integrated Process" found in *Electronic*  
25 *News*, January 20, 1997 issue. This reference is hereby incorporated by reference for purposes of explaining this particular type of imaging processor.

Another example of a recent development in solid state imaging is the development of CMOS imaging sensor which is able to achieve analog to digital conversion on each of the pixels within the pixel array. This type of improved CMOS imager includes transistors at every pixel to provide digital instead of analog output that enable the delivery of decoders and sense amplifiers much like standard memory chips. With this new technology, it may, therefore, be possible to manufacture a true digital "camera on a chip." This CMOS imager has been developed by a Stanford University joint project and is headed by Professor Abbas el-Gamal.

A second approach to creating a CMOS-based digital imaging device includes the use of an over-sample converter at each pixel with a one bit comparator placed at the edge of the pixel array instead of performing all of the analog to digital functions on the pixel. This new design technology has been called MOSAD (multiplexed over sample analog to digital) conversion. The result of this new process is low power usage, along with the capability to achieve enhanced dynamic range, possibly up to 20 bits. This process has been developed by Amain Electronics of Simi Valley, California. A brief description of both of the processes developed by Stanford University and Amain Electronics can be found in an article entitled "A/D Conversion Revolution for CMOS Sensor?," September 1998 issue of *Advanced Imaging*. This reference is also hereby incorporated by reference for purposes of explaining these particular types of imaging processors.

The above-mentioned developments in solid state imaging technology have shown that "camera on a chip" devices will continue to be enhanced not only in terms of the quality of imaging which may be



achieved, but also in the specific construction of the devices which may be manufactured by new breakthrough processes.

Although the "camera on a chip" concept is one which has great merit for application in many industrial areas, a need still exists for a  
5 reduced area imaging device which can be used in even the smallest type of endoscopic instruments in order to view areas in the body that are particularly difficult to access, and to further minimize patient trauma by an even smaller diameter invasive instrument.

It is one object of this invention to provide reduced area imaging  
10 devices which take advantage of "camera on a chip" technology, but rearrange the circuitry in a stacked relationship so that there is a minimum profile presented when used within a surgical instrument or other investigative device. It is another object of this invention to provide low cost imaging devices which may be "disposable." It is yet another object  
15 of this invention to provide reduced area imaging devices which may be used in conjunction with standard endoscopes by placing the imaging device through channels which normally receive other surgical devices, or receive liquids or gases for flushing a surgical area. It is yet another object of this invention to provide a surgical device with imaging capability which  
20 may be battery powered and only requires one conductor for transmitting a pre-video signal to video processing circuitry within or outside the sterile field of the surgical area.

In addition to the intended use of the foregoing invention with respect to surgical procedures conducted by medical doctors, it is also  
25 contemplated that the invention described herein has great utility with respect to oral surgery and general dental procedures wherein a very small imaging device can be used to provide an image of particularly difficult to

access locations. Additionally, while the foregoing invention has application with respect to the medical and dental fields, it will also be appreciated by those skilled in the art that the small size of the imaging device set forth herein can be applied to other functional disciplines wherein the imaging device can be used to view difficult to access locations for industrial equipment and the like. Therefore, the imaging device of this invention could be used to replace many industrial boroscopes.

The "camera on a chip" technology can be further improved with respect to reducing its profile area and incorporating such a reduced area imaging device into very small investigative instruments which can be used in the medical, dental, or other industrial fields.

#### **Disclosure of the Invention**

In accordance with the present invention, reduced area imaging devices are provided. The term "imaging device" as used herein describes the imaging elements and processing circuitry which is used to produce a video signal which may be accepted by a standard video device such as a television or video monitor accompanying a personal computer. The term "image sensor" as used herein describes the components of a solid state imaging device which captures images and stores them within the structure of each of the pixels in the array of pixels found in the imaging device. As further discussed below, the timing and control circuits can be placed either on the same planar structure as the pixel array, in which case the image sensor can also be defined as an integrated circuit, or the timing and control circuitry can be placed remote from the pixel array. The terms "signal" or "image signal" as used herein, and unless otherwise more specifically

defined, refer to an image which at some point during its processing by the imaging device, is found in the form of electrons which have been placed in a specific format or domain. The term "processing circuitry" as used herein refers to the electronic components within the imaging device which receive the image signal from the image sensor and ultimately place the image signal in a usable format. The terms "timing and control circuits" or "circuitry" as used herein refer to the electronic components which control the release of the image signal from the pixel array.

In a first embodiment, the image sensor, with or without the timing and control circuitry, may be placed at the distal tip of the endoscopic instrument while the remaining processing circuitry may be found in a small remote control box which may communicate with the image sensor by a single cable.

In a second embodiment, the image sensor and the processing circuitry may all be placed in a stacked arrangement of circuit boards and positioned at the distal tip of the endoscopic instrument. In this embodiment, the pixel array of the image sensor may be placed by itself on its own circuit board while the timing and control circuitry and processing circuitry are placed on one or more other circuit boards. Alternatively, the circuitry for timing and control may be placed with the pixel array on one circuit board, while the remaining processing circuitry can be placed on one or more of the other circuit boards.

In yet another embodiment, the imaging device may be adapted for use with a standard rod lens endoscope wherein the imaging device is placed within a standard camera housing which is configured to connect to a standard "C" or "V" mount connector.

A generic endoscope may be used in the first and second embodiments which includes a very small diameter tubular portion which is inserted within the patient. The tubular portion may be made of a flexible material having a central lumen or opening therein for receiving the elements of the imaging device. The tubular portion may be modified to include an additional concentric tube placed within the central lumen and which enables a plurality of light fibers to be placed circumferentially around the periphery of the distal end of the tubular portion. Additionally, control wires may extend along the tubular portion in order to make the endoscope steerable. The material used to make the endoscope can be compatible with any desired sterilization protocol, or the entire endoscope can be made sterile and disposable after use.

For the configuration of the imaging device which calls for the array of pixels and the timing and control circuitry to be placed on the same circuit board, only one conductor is required in order to transmit the image signal to the processing circuitry. In the other configuration of the imaging device wherein the timing and control circuits are incorporated onto other circuit boards, a plurality of connections are required in order to connect the timing and control circuitry to the pixel array and the one conductor is also required to transmit the image signal.

### **Brief Description of the Drawings**

Figure 1a illustrates a first embodiment including a fragmentary cross-sectional view of a generic endoscopic instrument, and a fragmentary perspective view of a control box, the endoscope and control box each incorporating elements of a reduced area imaging device;

Figure 1b is an enlarged fragmentary partially exploded perspective view of the distal end of the endoscopic instrument specifically illustrating the arrangement of the image sensor with respect to the other elements of the tubular portion of the endoscope;

5        Figure 2a is a fragmentary cross-sectional view of a second embodiment of this invention illustrating another generic endoscope wherein the imaging device is incorporated in its entirety at the distal tip of the endoscope;

10        Figure 2b is an enlarged fragmentary partially exploded perspective view of the distal end of the endoscope of Figure 2a illustrating the imaging device;

Figure 3a is an elevational fragmentary cross-sectional view of the image sensor incorporated with a standard camera housing for connection to a rod lens endoscope;

15        Figure 3b is a fragmentary cross-sectional view of the imaging device incorporated within the camera housing of Figure 3a;

Figure 3c is a fragmentary cross-sectional view similar to that of Figure 3b illustrating a battery as an alternate source of power;

20        Figure 4 is a schematic diagram of the functional electronic components which make up the imaging device;

Figure 4a is an enlarged schematic diagram of a circuit board which may include the array of pixels and the timing and control circuitry;

25        Figure 4b is an enlarged schematic diagram of a video processing board having placed thereon the processing circuitry which processes the pre-video signal generated by the array of pixels and which converts the pre-video signal to a post-video signal which may be accepted by a standard video device; and



Figures 5a-5e are schematic diagrams that illustrate an example of specific circuitry which may be used to make the imaging device.

### **Best Mode for Carrying Out the Invention**

- In accordance with one embodiment of the invention as shown in Figure 1a, an endoscope 10 is provided which incorporates a reduced area imaging device 11, shown in Figure 1b. As further discussed below, the elements of the imaging device may all be found at one location or the elements may be separated from one another and interconnected by the appropriate cable(s). The array of pixels making up the image sensor captures images and stores them in the form of electrical energy by conversion of light photons to electrons. This conversion takes place by the photo diodes in each pixel which communicate with one or more capacitors which store the electrons. The structure of the endoscope 10, includes a flexible or rigid tubular portion 14 which is inserted into the body of the patient and is placed at the appropriate location for viewing a desired surgical area. The tubular portion 14 attaches at its proximal end to a handle portion 12 which may be grasped by a surgeon who is conducting the endoscopic procedure. The handle 12 may include a central lumen or channel 13 which receives therethrough one or more cables or other structures which extend to the distal end 16 of tubular portion 14. Handle portion 12 may further include a supplementary channel 15 which intersects with central channel 13 and which may provide another point of entry for other cables, fluids or operative instruments to be placed through the endoscope.
- Figure 1b illustrates the distal end of the endoscope 16. The distal end 16 may be characterized by an outer tube 18 which traverses the length

of the tubular portion 14 and connects to the handle portion 12. Placed concentrically within the outer tube 18 may be one or more inner tubes 20. In Figure 1b, the gap between inner tube 20 and outer tube 18 forms a space in which one or more light fibers 22 or control wires 24 may be placed. As well understood by those skilled in the art, a plurality of circumferentially spaced light fibers as illustrated in Figure 1b can be used to illuminate the surgical site. Additionally, the control wires 24 may communicate with a control mechanism (not shown) integrated on the handle portion 12 for manipulating the distal end 16 of the endoscope in a desired direction. The flexible tubular portion 14 coupled with a steerable feature enables the endoscope to be placed within winding bodily passages or other locations difficult to reach within the body.

An image sensor 40 may be placed within the central channel defined by inner tube 20. In the configuration shown in Figure 1b, a cable 26 is used to house the conductors which communicate with the image sensor 40. An intermediate support tube 28 may be placed concentrically outside of cable 26 and concentrically within inner tube 20 to provide the necessary support for the cable 26 as it traverses through the inner channel defined by inner tube 20. In lieu of support tube 28, other well-known means may be provided to stabilize the cable 26 such as clips or other fastening means which may attach to the inner concentric surface of inner tube 20.

A control box 30 may be placed remote from the endoscope 10. The control box 30 contains some of the processing circuitry which is used to process the image signal produced by image sensor 40. Therefore, the imaging device 11 as previously defined would include the processing circuitry within control box 30 and the image sensor 40 located at the distal

tip of the endoscope. Control box 30 communicates with image sensor 40 by means of cable 32 which may simply be an insulated and shielded cable which houses therein cable 26. Cable 32 is stabilized with respect to the handle portion 12 by means of a fitting 34 which ensures that cable 32 cannot be inadvertently pushed or pulled within channel 13. Additionally, an additional fitting 35 may be provided to stabilize the entry of a light cable 36 which houses the plurality of light fibers 22.

Image sensor 40 is illustrated as being a planar and square shaped member. However, the image sensor may be modified to be in a planar and circular shape to better fit within the channel defined by inner tube 20. Accordingly, Figure 1b further shows an alternate shaped image sensor 40' which is round. A lens group or system 42 may be incorporated at the distal end of the endoscope in order to manipulate the image prior to it being impinged upon the array of pixels on the image sensor 40. This lens system 42 may be sealed at the distal end 16 of the endoscope so that the tubular portion 14 is impervious to fluids entering through the distal end 16. In the configuration of the imaging device 11 in Figures 1a and 1b, there are only three conductors which are necessary for providing power to the image sensor 40, and for transmitting an image from the image sensor 40 back to the processing circuitry found within control box 30. Namely, there is a power conductor 44, a grounding conductor 46, and an image signal conductor 48 each of which are hard wired to the image sensor. Thus, cable 26 may simply be a three-conductor 50 ohm cable.

Image sensor 40 can be as small as 1 mm in its largest dimension. However, a more preferable size for most endoscopic procedures would dictate that the image sensor 40 be between 4 mm to 8 mm in its largest dimension. The image signal transmitted from the image sensor through

conductor 48 is also herein referred to as a pre-video signal. Once the pre-video signal has been transmitted from image sensor 40 by means of conductor 48, it is received by video processing board 50. Video processing board 50 then carries out all the necessary conditioning of the pre-video signal and places it in a form so that it may be viewed directly on a standard video device, television or standard computer video monitor.

The signal produced by the video processing board 50 can be further defined as a post-video signal which can be accepted by a standard video device. As shown in Figure 1a, a conductor 49 is provided which transmits

the post-video signal to an output connector 58 on the exterior surface of control box 30. The cable (not shown) extending from the desired video device (not shown) may receive the post-video signal by means of connector 58. Power supply board 52 may convert incoming power

received through power source 54 into the desired voltage. In the preferred imager incorporated in this invention, the power to the imaging device is simply a direct current which can be a 1.5 volt to a 12 volt source.

Incoming power from, for example, a wall receptacle, communicates with power supply board 52 by connector 56. Power supply board 52 takes the incoming power source and regulates it to the desired level. Additionally, ground 46 is also shown as extending back to the source of power through connector 56.

Figure 2a illustrates a second embodiment of this invention wherein the imaging device is self-contained entirely within the distal end 16 of the endoscope, and a power source which drives the circuitry within the imaging device may come from a battery 66 housed within handle portion 12.

As shown in Figure 2b, the video processing board 50 may be placed directly behind image sensor 40. A plurality of pin connectors 62 serve to electrically couple image sensor 40 with video processing board 50 depending upon the specific configuration of image sensor 40, pin connectors 62 may be provided either for structural support only, or to provide a means by which image signals are transmitted between image sensor 40 and board 50. When necessary, one or more supplementary boards 60 may be provided which further contain processing circuitry to process the image signal and present it in a form which may be directly received by a desired video device. The area which is occupied by image sensor 40 may be defined as the profile area of the imaging device and which determines its critical dimensions. Any imaging elements that are found on boards 50 or 60 must be able to be placed on one or more circuit boards which are longitudinally aligned with image sensor 40 along longitudinal axis XX. If the profile area is not critical in terms of limiting the largest sized imaging element within the imaging device, then the additional circuit boards 50 and 60 which are normally placed in line with image sensor 40 can be aligned in an offset manner or may be larger than the profile area of image sensor 40. In the configuration of Figure 2b, it is desirable that elements 40, 50 and 60 be approximately the same size so that they may fit uniformly within the central channel of the endoscope. Additionally, image sensor 40 may be bonded to lens system 42 in order to provide further structural support to the imaging device 11 when mounted within the distal end 16.

Referring back to the handle portion 12 in Figure 2a, an additional channel 64 may be provided in order that a power supply cable 68 may communicate with battery 66. Conveniently, battery 66 may itself be



mounted within a well 65 formed in handle portion 12. Cable 68 carries the conductor 44 and ground 46. Cable 68 may intersect with cable 33 within channel 13, cables 68 and 33 extending then to the distal end 16. Cable 33 can be a single conductor cable which transmits the post-video signal to a desired video device. In other words, cable 33 may simply be an insulated and shielded housing for conductor 49 which carries the post-video signal. Because a preferred image sensor of the imaging device 11 may only require a 5 volt power supply, a battery is an ideal power source in lieu of a conductor which would trail the endoscope. Accordingly, the endoscope is made more mobile and easier to handle by eliminating at least one of the trailing cables.

Figure 3a illustrates yet another preferred embodiment of this invention, wherein the imaging device can be used in conjunction with a standard rod lens endoscope 70. As shown, rod lens endoscope 70 includes a lens train 72 which includes a plurality of highly precise lenses (not shown) which are able to transmit an image from the distal end of the endoscope, to a camera in line with the endoscope. The rod lens endoscope is equipped with a light guide coupling post 74. Light guide post 74 connects to a source of light in the form of a cable 77 having a plurality of fiber optic strands (not shown) which communicate with a source of light (not shown). The most common arrangement of the rod lens endoscope also includes a "C" or "V" mount connector 78 which attaches to the eyepiece 76. The "C" or "V" mount attaches at its other end to a camera group 80. The camera group 80 houses one or more of the elements of the imaging device. In this embodiment, the small size of the imaging device is not a critical concern since the imaging device is not being placed at the distal end of the endoscope. However, the incorporation of the imaging

device in a housing which would normally hold a traditional camera still provides an advantageous arrangement. As shown, the camera group 80 may include a housing 82 which connects to a power/video cable 86. Fitting 87 is provided to couple cable 86 to the interior elements of the camera group 80 found within housing 82. Figure 3a illustrates an arrangement of the imaging device 11 wherein the image sensor 40 is placed by itself within the housing 82 and the processing circuitry of the imaging device can be positioned in a remote control box as shown in Figure 1a. Accordingly, only three conductors 44, 46 and 48 are necessary for providing power to the image sensor 40 and for transmitting the pre-video signal to the control box. Alternatively, as shown in Figure 3b, the entire imaging device 11 may be incorporated within camera group 80, each of the elements of the imaging device being placed in the stacked arrangement similar to Figure 2b. As discussed above, size is not as much of a concern in the embodiment of Figure 3a and 3b since the camera group housing 82 is much larger than the distal tip of the endoscope of Figures 1a and 2a.

Figure 3c also illustrates the use of a battery 66 which provides source of power to the imaging device in either Figure 3a or 3b. In this arrangement, housing 82 is altered to include a battery housing 69 which houses the battery 66 therein. Battery housing 69 may include a very small diameter channel which may allow conductor 48 or 49 to communicate directly with the processing circuitry or video device, respectively. It will also be understood that the embodiment in Figure 1a may incorporate the use of a battery 66 as the source of power. Thus, handle 12 in Figure 1a may be altered in the same way as housing 82 to allow a battery to be attached to the handle portion 12.

Figure 4 is a schematic diagram illustrating one way in which the imaging device 11 may be constructed. As illustrated, the image sensor 40 may include the timing and control circuits on the same planar structure. Power is supplied to image sensor 40 by power supply board 52. The connection between image sensor 40 and board 52 may simply be a cable having two conductors therein, one for ground and another for transmitting the desired voltage. These are illustrated as conductors 44 and 46. The output from image sensor 40 in the form of the pre-video signal is input to video processor board 50 by means of the conductor 48. In the configuration of Figure 4, conductor 48 may simply be a 50 ohm conductor. Power and ground also are supplied to video processing board 50 by conductors 44 and 46 from power supply board 52. The output signal from the video processor board 50 is in the form of the post-video signal and which may be carried by conductor 49 which can also be a 50 ohm conductor.

In the first embodiment illustrated in Figure 1a, cable 32 can be used to house conductors 44, 46 and 48. In the embodiment shown in Figure 2a, cable 33 can be used to house conductor 49 by itself when a battery power source is used, or alternatively, cable 33 may house conductors 44, 46 and 49 if the embodiment of Figure 2a utilizes a power source from board 52.

Optionally, a supplementary processing board 60 may be provided to further enhance the pre-video signal. As shown in Figure 4, the supplementary board 60 may be placed such that the pre-video signal from image sensor 40 is first sent to the supplementary board and then output to the video processor board 50. In this case, the output from board 50 can be carried along conductor 51. This output can be defined as an enhanced pre-video signal. Furthermore, the post-video signal from video processor

board 50 may return to the supplementary board 60 for further processing, as further discussed below. The conductor used to transmit the post-video signal back to the supplementary board is shown as conductor 59. The power supply board 52 may also provide power to the supplementary board in the same manner as to image sensor 40 and board 50. That is, a simple hard-wired connection is made onto the supplementary board for the ground and voltage carrying conductors. As discussed above, image sensor 40 may be placed remotely from boards 50 and 60. Alternatively, image sensor 40, and boards 50 and 60 each may be placed within the distal end of the endoscope.

Although Figure 4 illustrates the image sensor and the timing and control circuits being placed on the same planar structure, it is possible to separate the timing and control circuits from the pixel array and place the timing and control circuits onto video processing board 50. The advantage in placing the timing and control circuits on the same planar structure as the image sensor is that only three connections are required between image sensor 40 and the rest of the imaging device, namely, conductors 44, 46 and 48. Additionally, placing the timing and control circuits on the same planar structure with the pixel array results in the pre-video signal having less noise. Furthermore, the addition of the timing and control circuits to the same planar structure carrying the image sensor only adds a negligible amount of size to one dimension of the planar structure. If the pixel array is to be the only element on the planar structure, then additional connections must be made between the planar structure and the video processing board 50 in order to transmit the clock signals and other control signals to the pixel array. For example, a ribbon-type cable (not shown) or a plurality of 50 ohm coaxial cables (not shown) must be used in order to

control the downloading of information from the pixel array. Each of these additional connections would be hard wired between the boards.

Figure 4a is a more detailed schematic diagram of image sensor 40 which contains an array of pixels 90 and the timing and control circuits 92.

5 One example of a pixel array 90 which can be used within the invention is similar to that which is disclosed in U.S. Patent No. 5,471,515 to Fossum, et al., said patent being incorporated by reference herein. More specifically, Figure 3 of Fossum, et al. illustrates the circuitry which makes up each pixel in the array of pixels 90. The array of pixels 90 as described  
10 in Fossum, et al. is an active pixel group with intra-pixel charged transfer. The image sensor made by the array of pixels is formed as a monolithic complementary metal oxide semiconductor integrated circuit which may be manufactured in an industry standard complementary metal oxide semiconductor process. The integrated circuit includes a focal plane array  
15 of pixel cells, each one of the cells including a photo gate overlying the substrate for accumulating the photo generated charges. In broader terms, as well understood by those skilled in the art, an image impinges upon the array of pixels, the image being in the form of photons which strike the photo diodes in the array of pixels. The photo diodes or photo detectors  
20 convert the photons into electrical energy or electrons which are stored in capacitors found in each pixel circuit. Each pixel circuit has its own amplifier which is controlled by the timing and control circuitry discussed below. The information or electrons stored in the capacitors is unloaded in the desired sequence and at a desired frequency, and then sent to the video  
25 processing board 50 for further processing.

Although the active pixel array disclosed in U.S. Patent No. 5,471,515 is mentioned herein, it will be understood that the hybrid



CCD/CMOS described above, or any other solid state imaging device may be used wherein timing and control circuits can be placed either on the same planar structure with the pixel array, or may be separated and placed remotely. Furthermore, it will be clearly understood that the invention  
 5 claimed herein is not specifically limited to an image sensor as disclosed in the U.S. Patent No. 5,471,515, but encompasses any image sensor which may be configured for use in conjunction with the other processing circuitry which makes up the imaging device of this invention.

The timing and control circuits 92 are used to control the release of  
 10 the image information or image signal stored in the pixel array. In the image sensor of Fossum, et al., the pixels are arranged in a plurality of rows and columns. The image information from each of the pixels is first consolidated in a row by row fashion, and is then downloaded from one or more columns which contain the consolidated information from the rows.  
 15 As shown in Figure 4a, the control of information consolidated from the rows is achieved by latches 94, counter 96, and decoder 98. The operation of the latches, counter and decoder is similar to the operation of similar control circuitry found in other imaging devices. That is, a latch is a means of controlling the flow of electrons from each individual addressed pixel in  
 20 the array of pixels. When a latch 94 is enabled, it will allow the transfer of electrons to the decoder 98. The counter 96 is programmed to count a discrete amount of information based upon a clock input from the timing and control circuits 92. When the counter 96 has reached its set point or overflows, the image information is allowed to pass through the latches 94  
 25 and be sent to the decoder 98 which places the consolidated information in a serial format. Once the decoder 98 has decoded the information and placed it in the serial format, then the row driver 100 accounts for the serial

information from each row and enables each row to be downloaded by the column or columns. In short, the latches 94 will initially allow the information stored in each pixel to be accessed. The counter 96 then controls the amount of information flow based upon a desired time sequence. Once the counter has reached its set point, the decoder 98 then knows to take the information and place it in the serial format. The whole process is repeated, based upon the timing sequence that is programmed. When the row driver 100 has accounted for each of the rows, the row driver reads out each of the rows at the desired video rate.

The information released from the column or columns is also controlled by a series of latches 102, a counter 104 and a decoder 106. As with the information from the rows, the column information is also placed in a serial format which may then be sent to the video processing board 50. This serial format of column information is the pre-video signal carried by conductor 48. The column signal conditioner 108 places the column serial information in a manageable format in the form of desired voltage levels. In other words, the column signal conditioner 108 only accepts desired voltages from the downloaded column(s).

The clock input to the timing and control circuits 92 may simply be a quartz crystal timer. This clock input is divided into many other frequencies for use by the various counters. The run input to the timing and control circuit 92 may simply be an on/off control. The default input can allow one to input the pre-video signal to a video processor board which may run at a frequency of other than 30 hertz. The data input controls functions such as zoom. At least for a CMOS type active pixel array which can be accessed in a random manner, features such as zoom

are easily manipulated by addressing only those pixels which locate a desired area of interest by the surgeon.

A further discussion of the timing and control circuitry which may be used in conjunction with an active pixel array is disclosed in U.S. Patent  
 5 No. 5,471,515 and is also described in an article entitled "Active Pixel Image Sensor Integrated With Readout Circuits" appearing in *NASA Tech Briefs*, October 1996, pp. 38 and 39. This particular article is also incorporated by reference.

Once image sensor 40 has created the pre-video signal, it is sent to  
 10 the video processing board 50 for further processing. At board 50, as shown in Figure 4b, the pre-video signal is passed through a series of filters. One common filter arrangement may include two low pass filters 114 and 116, and a band pass filter 112. The band pass filter only passes low frequency components of the signal. Once these low frequency  
 15 components pass, they are then sent to detector 120 and white balance circuit 124, the white balance circuit distinguishing between the colors of red and blue. The white balance circuit helps the imaging device set its normal, which is white. The portion of the signal passing through low pass filter 114 then travels through gain control 118 which reduces the  
 20 magnitude or amplitude of this portion to a manageable level. The output from gain control 118 is then fed back to the white balance circuit 124. The portion of the signal traveling through filter 116 is placed through the processor 122. In the processor 122, the portion of the signal carrying the luminance or non-chroma is separated and sent to the Y chroma mixer 132.  
 25 Any chroma portion of the signal is held in processor 122.

Referring to the output of the white balance circuit 124, this chroma portion of the signal is sent to a delay line 126 where the signal is then

further reduced by switch 128. The output of switch 128 is sent through a balanced modulator 130 and also to the Y chroma mixer 132 where the processed chroma portion of the signal is mixed with the processed non-chroma portion. Finally, the output from the Y chroma mixer 132 is sent to

5 the NTSC/PAL encoder 134, commonly known in the art as a "composite" encoder. The composite frequencies are added to the signal leaving the Y chroma mixer 132 in encoder 134 to produce the post-video signal which may be accepted by a television.

Referring back to Figure 4, it further illustrates supplementary board

10 60 which may be used to digitally enhance or otherwise further condition the pre-video signal produced from image sensor 40. For example, digital enhancement can brighten or otherwise clarify the edges of an image viewed on a video screen. Additionally, the background images may be removed thus leaving only the foreground images or vice versa. The

15 connection between image sensor 40 and board 60 may simply be the conductor 48 which may also transfer the pre-video signal to board 50. Once the pre-video signal has been digitally enhanced on supplementary board 60, it is then sent to the video processor board 50 by means of another conductor 51. The pre-video signal is an analog signal. The

20 digitally enhanced pre-video signal may either be a digital signal or it may be converted back to the analog domain prior to being sent to board 50.

In addition to digital enhancement, supplementary board 60 may further include other circuitry which may further condition the post-video signal so that it may be viewed in a desired format other than NTSC/PAL.

25 As shown in Figures 4, intermediate conductor 59 may transmit the signal output from Y chroma mixer 132 back to the supplementary board 60 where the signal is further encoded for viewing in a particular format. One

common encoder which can be used includes an RGB encoder 154. The RGB encoder separates the signal into three separate colors (red, green and blue) so that the surgeon may selectively choose to view only those images containing one or more of the colors. Particularly in tissue analysis where  
5 dyes are used to color the tissue, the RGB encoder may help the surgeon to identify targeted tissue.

The next encoder illustrated in Figure 4 is a SVHS encoder 156 (super video home system). This encoder splits or separates the luminance portion of the signal and the chroma portion of the signal prior to entering  
10 the video device. Some observers believe that a cleaner signal is input to the video device by such a separation which in turn results in a more clear video image viewed on the video device. The last encoder illustrated in Figure 4 is a VGA encoder 158 which enables the signal to be viewed on a standard VGA monitor which is common to many computer monitors.

15 One difference between the arrangement of image sensor 40 and the outputs found in Figure 3 of the Fossum, et al. patent is that in lieu of providing two analog outputs [namely, VS out (signal) and VR out (reset)], the reset function takes place in the timing and control circuitry 92. Accordingly, the pre-video signal only requires one conductor 48.

20 Figures 5a-5e illustrate in more detail one example of circuitry which may be used in the video processing board 50 in order to produce a post-video signal which may be directly accepted by a video device such as a television. The circuitry disclosed in Figures 5a-5e is very similar to circuitry which is found in a miniature quarter-inch Panasonic camera,  
25 Model KS-162. It will be understood by those skilled in the art that the particular arrangement of elements found in Figures 5a-5e are only exemplary of the type of video processing circuitry which may be



incorporated in order to take the pre-video signal and condition it to be received by a desired video device.

As shown in Figure 5a, 5 volt power is provided along with a ground by conductors 44 and 46 to board 50. The pre-video signal carried by conductor 48 is buffered at buffer 137 and then is transferred to amplifying group 138. Amplifying group 138 amplifies the signal to a usable level as well as achieving impedance matching for the remaining circuitry.

The next major element is the automatic gain control 140 shown in Figure 5b. Automatic gain control 140 automatically controls the signal from amplifying group 138 to an acceptable level and also adds other characteristics to the signal as discussed below. More specifically, automatic gain control 140 conditions the signal based upon inputs from a 12 channel digital to analog converter 141. Converter 141 retrieves stored information from EEPROM (electrically erasable programmable read only memory) 143. EEPROM 143 is a non-volatile memory element which may store user information, for example, settings for color, tint, balance and the like. Thus, automatic gain control 140 changes the texture or visual characteristics based upon user inputs. The signal leaving the automatic gain control 140 is an analog signal until being converted by analog to digital converter 142.

Digital signal processor 144 of Figure 5c further processes the converted signal into a serial type digital signal. One function of the microprocessor 146 is to control the manner in which digital signal processor 144 sorts the digital signals emanating from converter 142. Microprocessor 146 also controls analog to digital converter 142 in terms of when it is activated, when it accepts data, when to release data, and the

rate at which data should be released. Microprocessor 146 may also control other functions of the imaging device such as white balance. The microprocessor 146 may selectively receive the information stored in the EEPROM 143 and carry out its various commands to further control the other elements within the circuitry.

After the signal is processed by digital signal processor 144, the signal is sent to digital encoder 148 illustrated in Figure 5d. Some of the more important functions of digital encoder 148 are to encode the digital signal with synchronization, modulated chroma, blanking, horizontal drive, and the other components necessary so that the signal may be placed in a condition for reception by a video device such as a television monitor. As also illustrated in Figure 5d, once the signal has passed through digital encoder 148, the signal is reconverted into an analog signal through digital to analog converter 150.

This reconverted analog signal is then buffered at buffers 151 and then sent to amplifier group 152 of Figure 5e which amplifies the signal so that it is readily accepted by a desired video device. Specifically, as shown in Figure 5e, one SVHS outlet is provided at 160, and two composite or NTSC outlets are provided at 162 and 164, respectively.

From the foregoing, it is apparent that an entire imaging device may be incorporated within the distal tip of an endoscope, or may have some elements of the imaging device being placed in a small remote box adjacent to the endoscope. Based upon the type of image sensor used, the profile area of the imaging device may be made small enough to be placed into an endoscope which has a very small diameter tube. Additionally, the imaging device may be placed into the channels of existing endoscopes to provide additional imaging capability without increasing the size of the

endoscope. The imaging device may be powered by a standard power input connection in the form of a power cord, or a small lithium battery may be used.

This invention has been described in detail with reference to  
5 particular embodiments thereof, but it will be understood that various other modifications can be effected within the spirit and scope of this invention.

CLAIMS**What is claimed is:**

*Sub-D'* →

1. A reduced area imaging device comprising:
  - an image sensor lying in a first plane and including an array of pixels for receiving images thereon, said image sensor further including circuitry means on said first plane and coupled to said array of pixels for
  - 5 timing and control of said array of pixels, said image sensor producing a pre-video signal;
  - a pre-video conductor for transmitting said pre-video signal, said pre-video conductor having first and second ends, said first end communicating with said image sensor;
  - 10 a first circuit board lying in a second plane and longitudinally aligned with said image sensor, said first circuit board being connected to said pre-video conductor at said second end thereof, said first circuit board including circuitry means for converting said pre-video signal to a post-video signal for reception by a standard video device; and
  - 15 a power supply electrically coupled with said image sensor for driving said array of pixels and said timing and control means, and electrically coupled to said first circuit board for driving said circuit board.
  
2. A reduced area imaging device, as claimed in claim 1, wherein:
  - said image sensor defines a profile area in said first plane,
  - and said first circuit board being positioned so as not to extend
  - 5 substantially beyond said profile area.

3. A reduced area imaging device, as claimed in claim 1, further including:

a second circuit board electrically coupled with said first circuit board and said image sensor for enhancing said pre-video signal prior to reception by said <sup>first</sup> circuit board, said second circuit board being longitudinally aligned with said first circuit board and said image sensor so as not to extend substantially beyond said profile area.

4. A reduced area imaging device, as claimed in claim 1, wherein:

said first and second planes are offset from and substantially parallel to one another.

5. A reduced area imaging device, as claimed in claim 3, wherein:

said second circuit board lies in a third plane which is offset from and extends substantially parallel to said first and second planes.

*Sub D2* 6. A reduced area imaging device comprising:  
 an image sensor lying in a first plane and including an array of pixels for receiving images thereon, said image sensor further including circuitry means on said first plane and coupled to said array of pixels for timing and control of said array of pixels, said image sensor producing a pre-video signal;  
 a control box remote from said image sensor, said control box including circuitry means for receiving said pre-video signal from said

- image sensor, and for converting said pre-video signal to a post-video  
 10 signal which may be received by a standard video device; and  
 a power supply coupled to said control box and said image  
 sensor for providing power thereto.

7. A reduced area imaging device, as claimed in claim 6,  
 wherein said control box further includes:

- a supplementary circuit board for digitally enhancing the pre-  
 video signal, said supplementary circuit board coupled to said circuitry  
 5 means for receiving said pre-video signal and for converting said pre-video  
 signal.

ADDA1

add C<sup>2</sup>

ADDF2



ABSTRACT

5 A reduced area imaging device is provided for use in medical or  
dental instruments such as an endoscope. In one configuration of the  
imaging device, the image sensor is placed remote from the remaining  
circuitry. In another configuration, all of the circuitry to include the image  
10 sensor is placed in a stacked fashion at the same location. In a first  
embodiment of the invention, the entire imaging device can be placed at the  
distal tip of an endoscope. In a second embodiment, the image sensor is  
remote from the remaining circuitry according to the first configuration,  
and wherein a control box can be provided which communicates with the  
15 image sensor and is placed remotely from the endoscope. In yet another  
embodiment, the imaging device can be incorporated in the housing of a  
standard medical camera which is adapted for use with traditional rod lens  
endoscopes. In any of the embodiments, the image sensor may be placed  
alone on a first circuit board, or timing and control circuits may be included  
20 on the first circuit board containing the image sensor. One or more video  
processing boards can be stacked in a longitudinal fashion with respect to  
the first board, or the video processing boards may be placed in the control  
box.

1073-1009

Please type a plus sign (+) inside this box → ☒**DECLARATION FOR UTILITY OR  
DESIGN PATENT APPLICATION  
(37 CFR 1.63)**

☒ Declaration Submitted with Initial Filing    ☐ Declaration Submitted after Initial Filing (surcharge [37 CFR 1.16(e)] required)

Attorney Docket Number: F97.13 CIP2  
First Named Inventor: Edwin L. Adair, et al.

**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

"Reduced Area Imaging Devices"

the specification of which

☒ is attached hereto

OR

☐ was filed on (MM/DD/YY) \_\_\_\_\_ as United States Application Number or PCT International Application Number \_\_\_\_\_ as was amended on (MM/DD/YY) \_\_\_\_\_ (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 referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 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, listed below and have also identified below, by checking the box, any foreign application for patent or Inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

**Prior Foreign Application(s)**

| (Number) | (Country) | (Foreign Filing Date) | Priority Not Claimed                | Certified Copy Attached ? |                          |
|----------|-----------|-----------------------|-------------------------------------|---------------------------|--------------------------|
|          |           |                       |                                     | Yes                       | No                       |
| _____    | _____     | _____                 | <input checked="" type="checkbox"/> | <input type="checkbox"/>  | <input type="checkbox"/> |
| _____    | _____     | _____                 | <input type="checkbox"/>            | <input type="checkbox"/>  | <input type="checkbox"/> |

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached.

I hereby claim the benefit under 35 U.S.C. 119(e) of the United States provisional application(s) listed below.

| (Application Number) | (Filing Date) |
|----------------------|---------------|
| _____                | _____         |
| _____                | _____         |

☐ Additional provisional application numbers are listed on supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under 35 U.S.C. §120 of any United States application(s), or §365(c) of any PCT International application designating the United States, 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 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. 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>08/944,322</u>                               | <u>October 6, 1997</u> | <u>pending</u>                          |
| U.S. Parent Application or PCT<br>Parent Number | Parent Filing Date     | Parent Patent Number<br>(if applicable) |

|   |                    |   |
|---|--------------------|---|
| U.S. Parent Application or PCT<br>Parent Number | Parent Filing Date | Parent Patent Number<br>(if applicable) |
|---|--------------------|---|

☐ Additional U.S. or PCT International application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached.

As named inventor, I hereby appoint the following practitioner(s) to prosecute this application and to transact all business in the

Patent and Trademark Office connected therewith: ☒ Registered Practitioner(s) name/registration number listed below

| Name                    | Registration Number |
|-------------------------|---------------------|
| <u>Gary D. Fields</u>   | <u>19,604</u>       |
| <u>Brent P. Johnson</u> | <u>38,031</u>       |

☐ Additional registered practitioner(s) named on Supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: Fields & Johnson, P.C.  
1700 Lincoln Street, Suite 3030, Denver, CO 80203  
Country: U.S.A. Telephone: (303) 861-9100 Fax: (303) 861-9111

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 18 U.S.C. 1001 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  
Given Name (first and middle [if any]) Edwin L. Family Name or Surname Adair

Inventor's signature Edwin L. Adair Date Oct 10 1998  
Residence 317 Paragon Way Citizenship U.S.A.  
Post Office Address 317 Paragon Way  
City, State, Zip, Country Castle Pines Village, CO 80104  
Full name of second joint inventor, if any (given name, family name) Jeffrey L. Adair  
Second Inventor's signature Jeffrey L. Adair Date 10-30-98  
Residence 1861 East Redfox Place Citizenship U.S.A.  
Post Office Address 1861 East Redfox Place  
City, State, Zip, Country Highlands Ranch, CO 80126

☒ Additional inventors are being named on separately numbered sheets attached hereto.

DECLARATION FOR PATENT APPLICATION

Attorney Docket No. F97.13.CIP2

Full name of third joint inventor, if any (given name, family name) Randall S. Adair  
Third Inventor's signature *Randall S. Adair* Date 10-20-98  
Residence 3082 South Flamingo Way Citizenship U.S.A.  
Post Office Address 3082 South Flamingo Way  
Denver, CO 80222

10175685-102748

Applicant or Patentee: Edwin L. Adair, Jeffrey L. Adair, Randall S. Adair Attorney's  
 Serial No. or Patent No.: \_\_\_\_\_ Docket No.: F97.13CIP2  
 Filed or Issued: \_\_\_\_\_  
 For: "Reduced Area Imaging Devices"

**VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY  
 STATUS (37 CFR 1.9(f) AND 1.27(b)) - INDEPENDENT INVENTOR**

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled \_\_\_\_\_  
"Reduced Area Imaging Devices"  
 described in:

- ☒ the specification filed herewith.  
☐ application serial no. \_\_\_\_\_, filed \_\_\_\_\_  
☐ patent no. \_\_\_\_\_, issued \_\_\_\_\_

I have not assigned, granted, conveyed or licensed and am under no obligation under contract or law to assign, grant, convey or license, any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey or license any rights in the invention is listed below:

- ☒ no such person, concern or organization.

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate (37 CFR 1.28(b)).

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, any patent issuing thereon, or any patent to which this verified statement is directed.

Edwin L. Adair  
 NAME OF INVENTOR:

Jeffrey L. Adair  
 NAME OF INVENTOR:

Randall S. Adair  
 NAME OF INVENTOR:

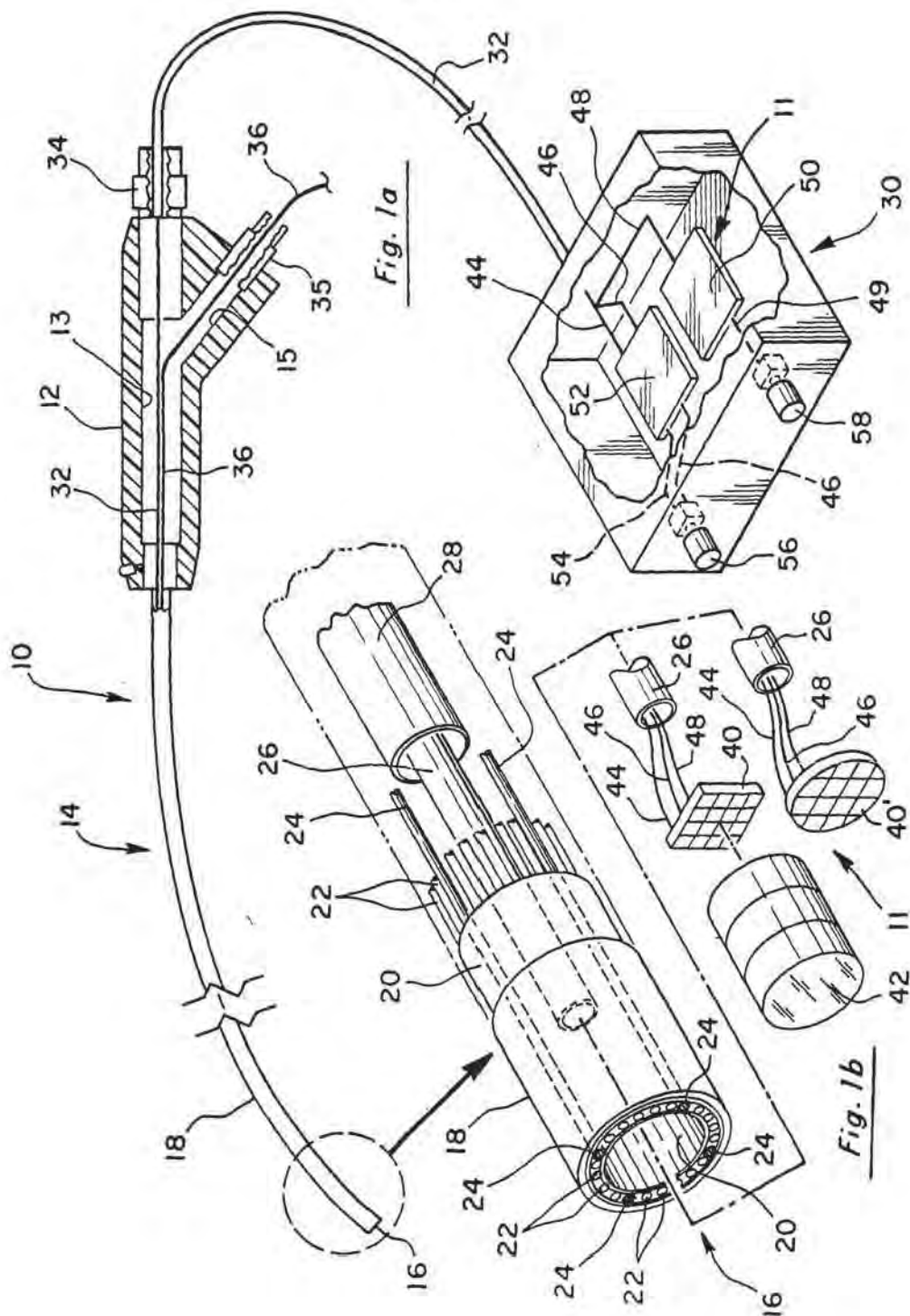
Edwin L. Adair  
 Signature of Inventor:

Jeffrey L. Adair  
 Signature of Inventor:

Randall S. Adair  
 Signature of Inventor:

$$\begin{array}{r} 348 \\ \hline 76 \end{array}$$

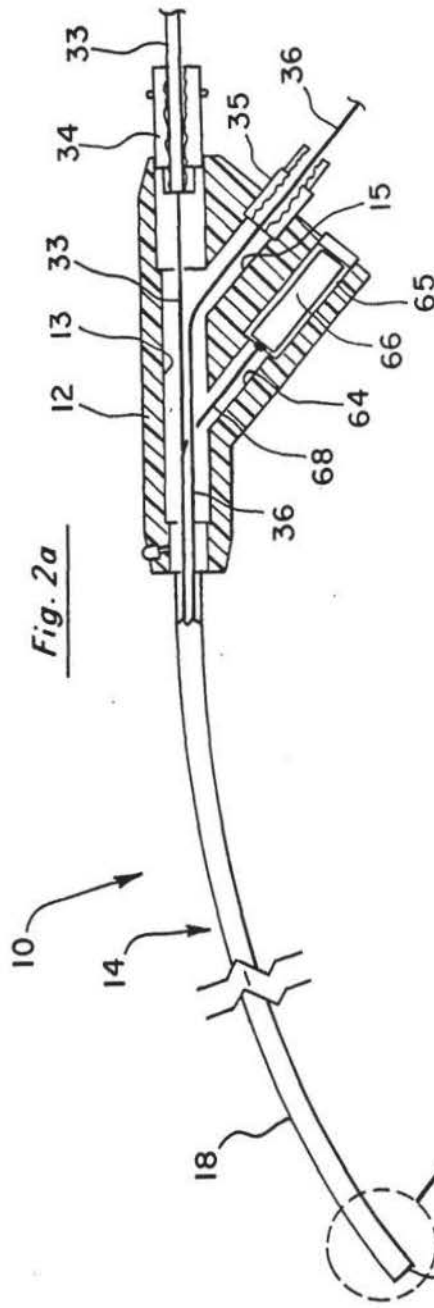
1/11



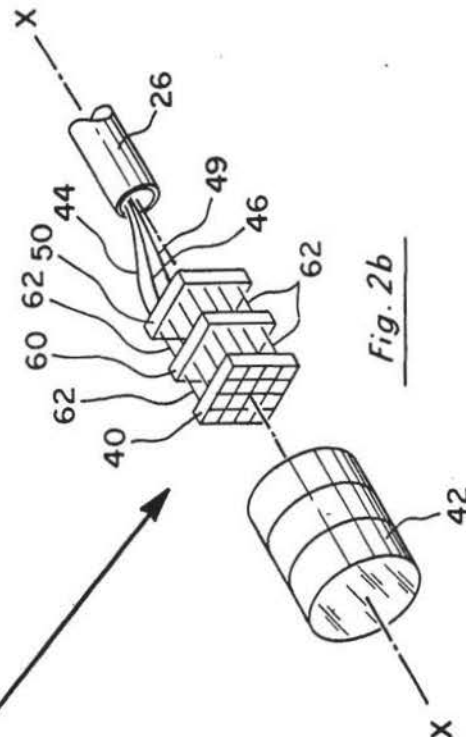


2/11

Fig. 2a

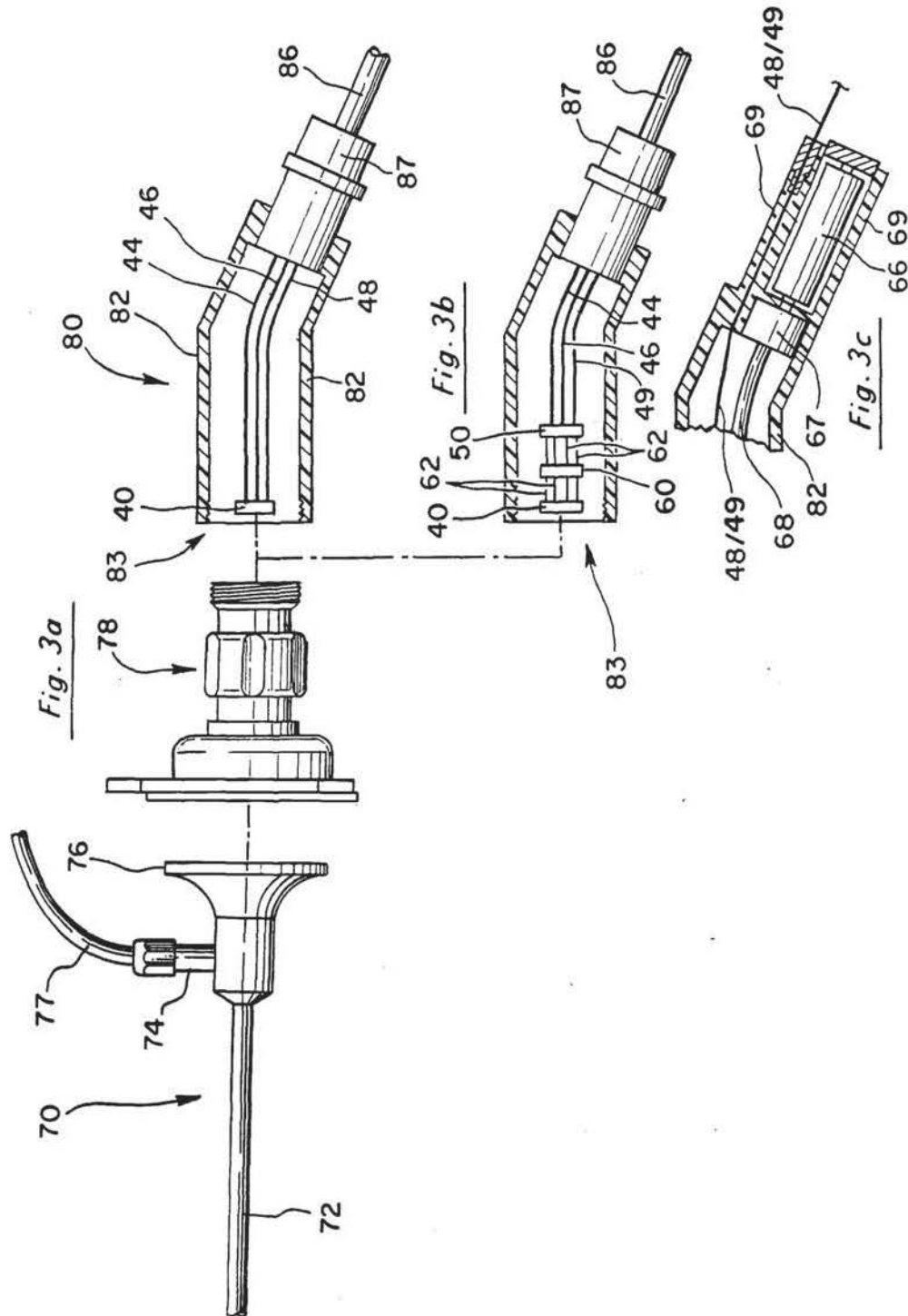


*Fig. 2b*



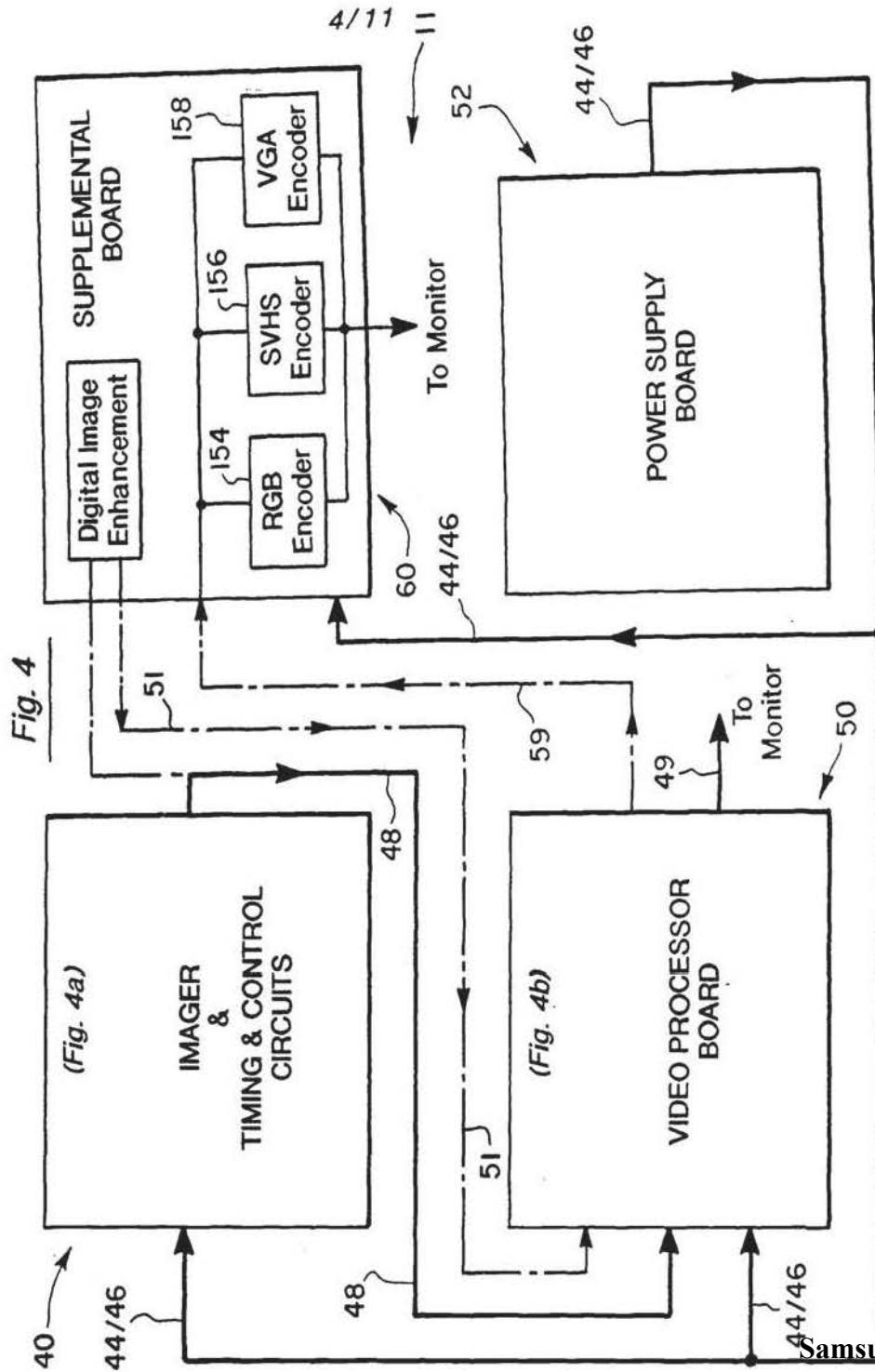
3/11

860201-5895/T60



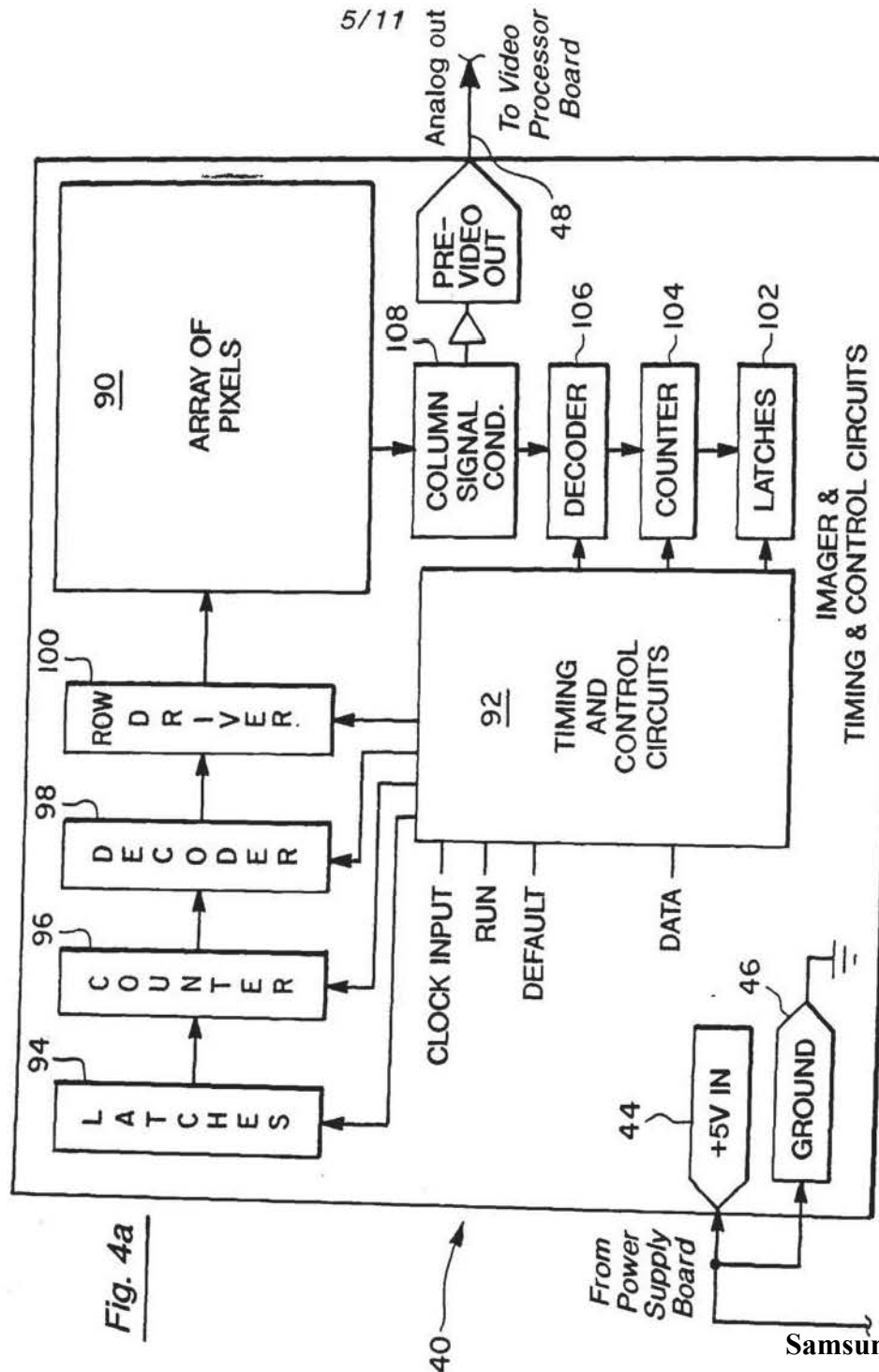
860201-58957160

PRINT OF DRAWINGS  
AS ORIGINALLY FILED



PRINT OF DRAWINGS  
AS ORIGINALLY FILED

860201-5895/T60



PRINT OF DRAWINGS  
AS ORIGINALLY FILED

6/11

860201-5895ZT60

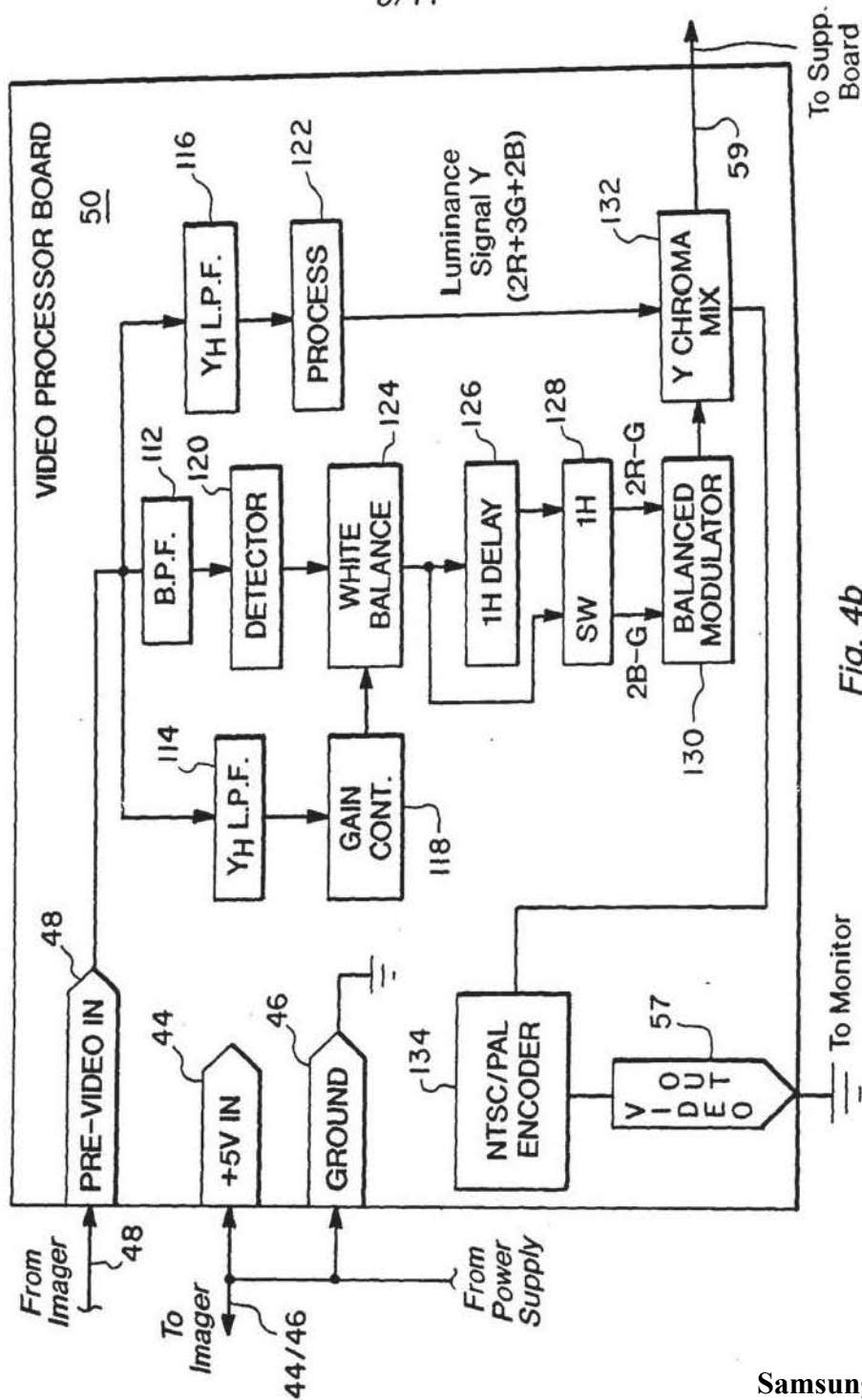
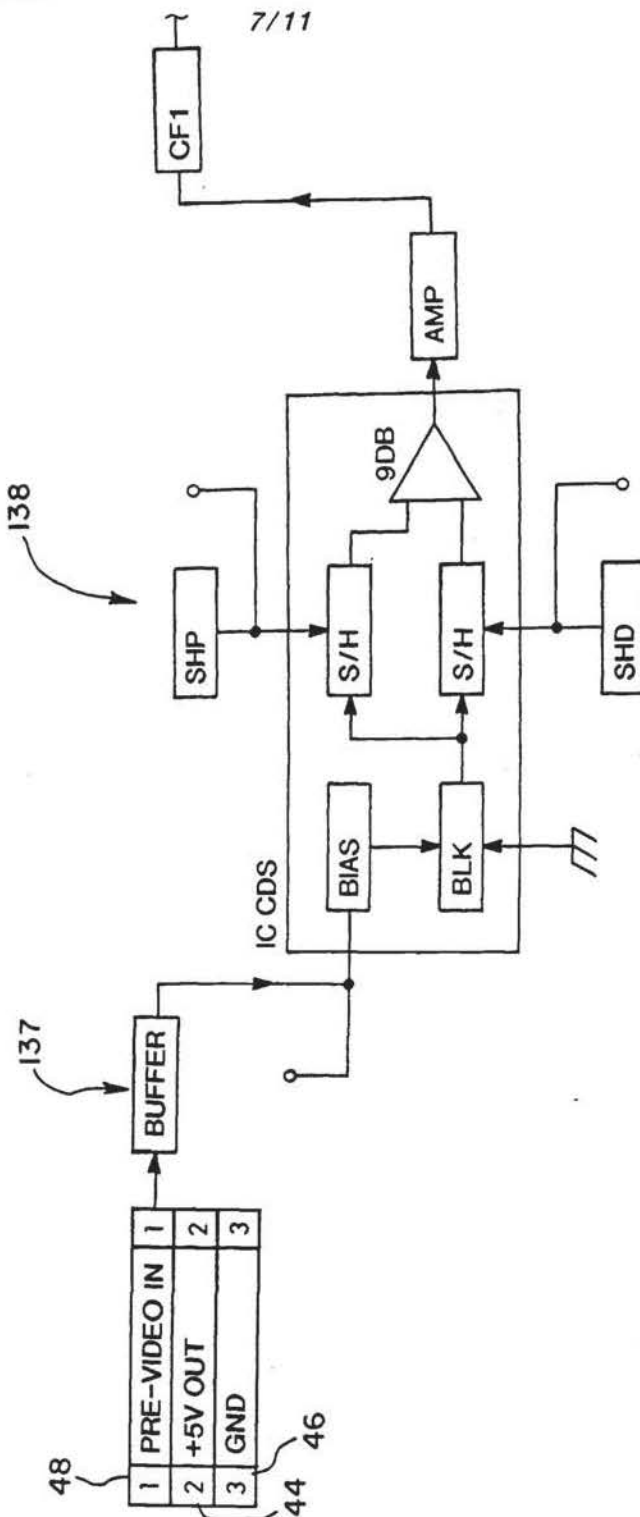


Fig. 4b

860201-5895/T60

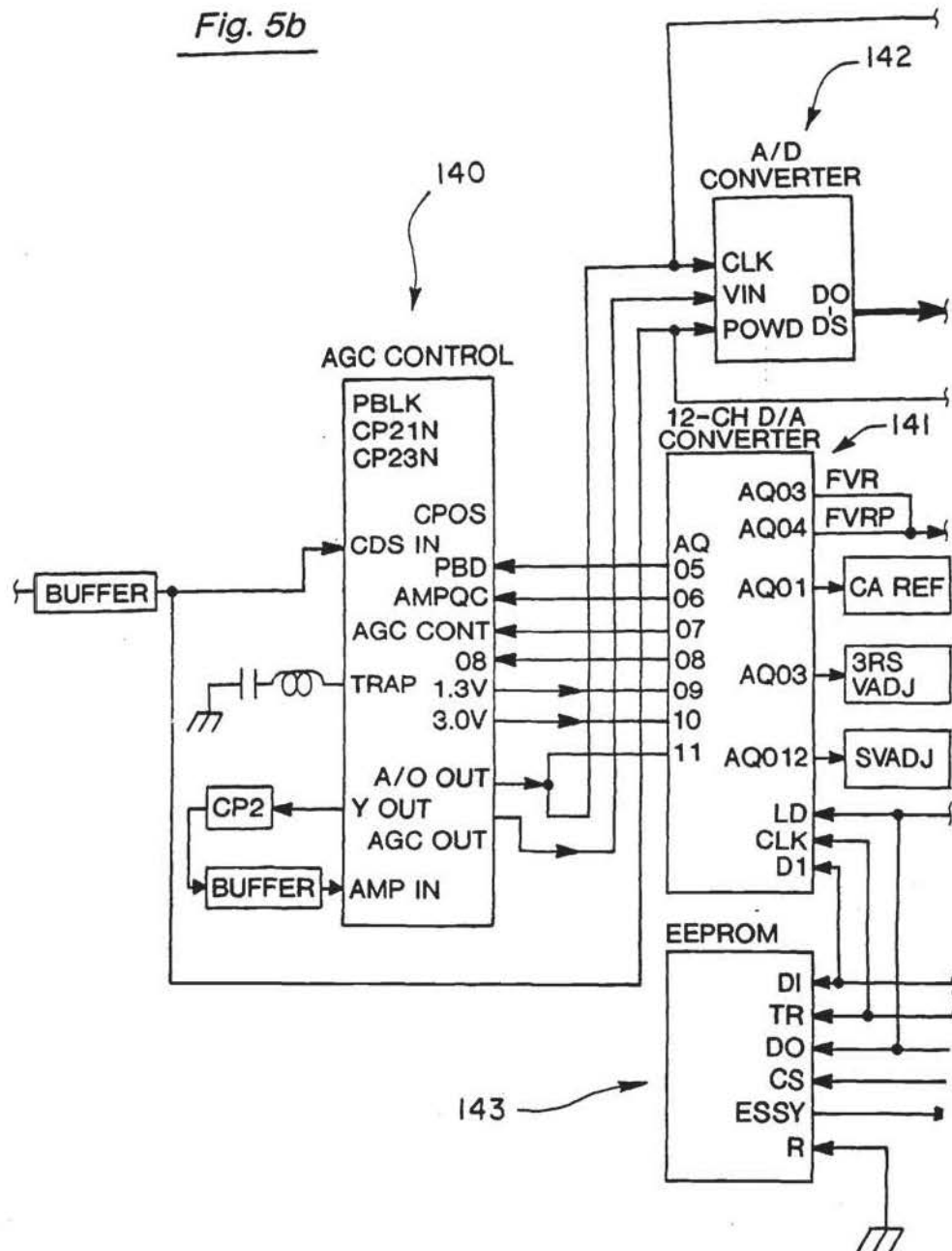
Fig. 5a





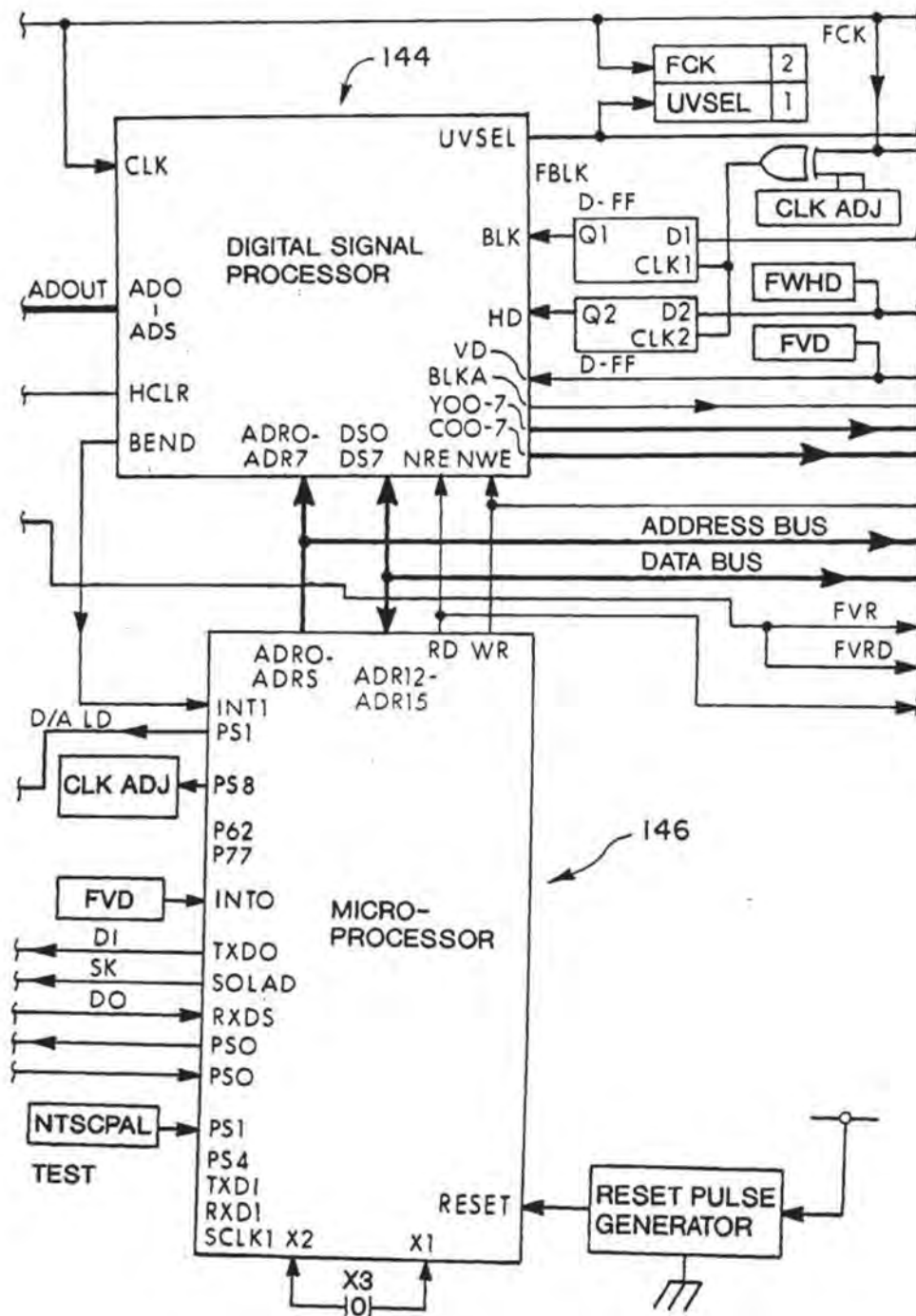
8/11

Fig. 5b



09175685.102098

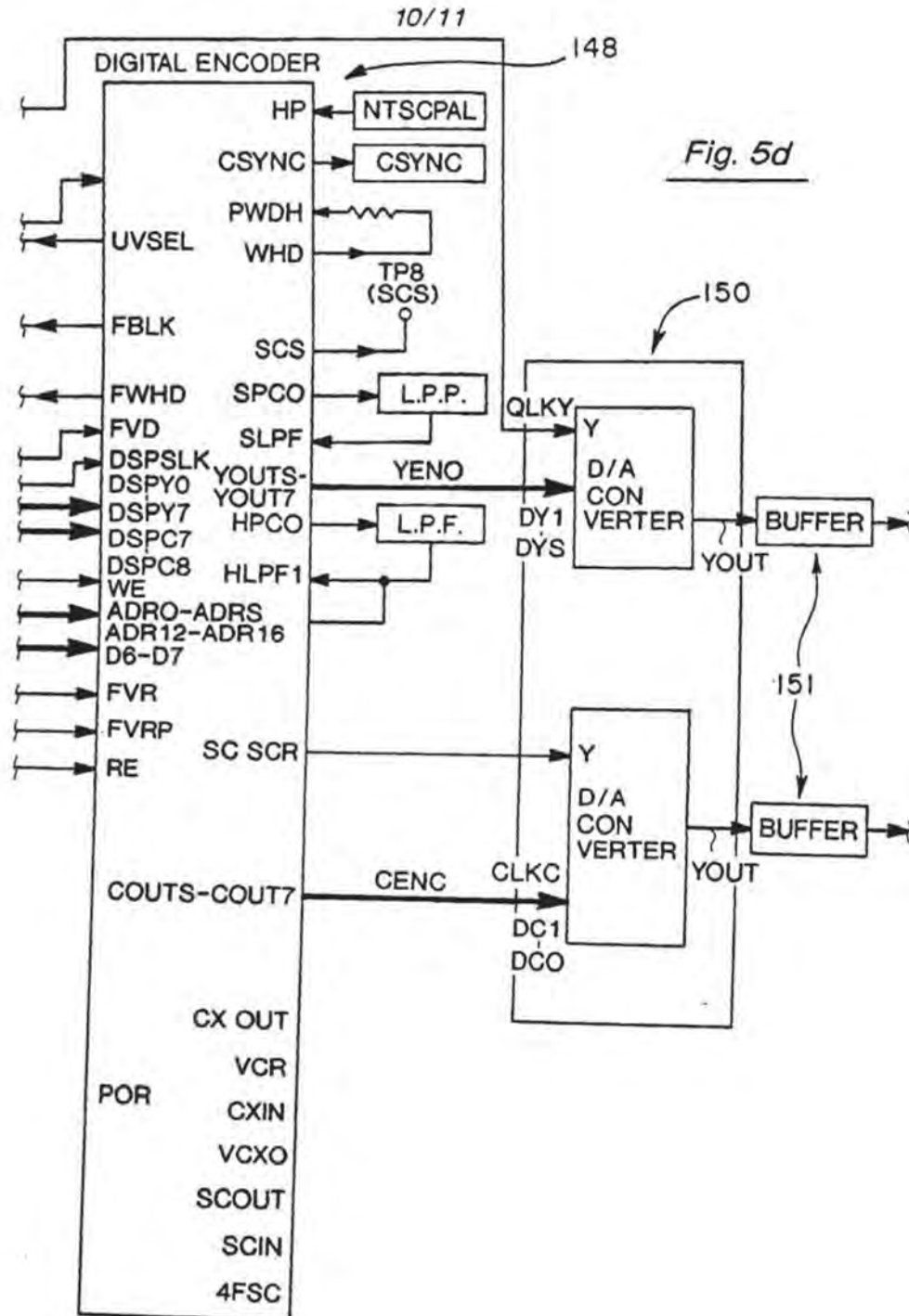
9/11 Fig. 5c



09175685.102096

PRINT OF DRAWINGS  
AS ORIGINALLY FILED

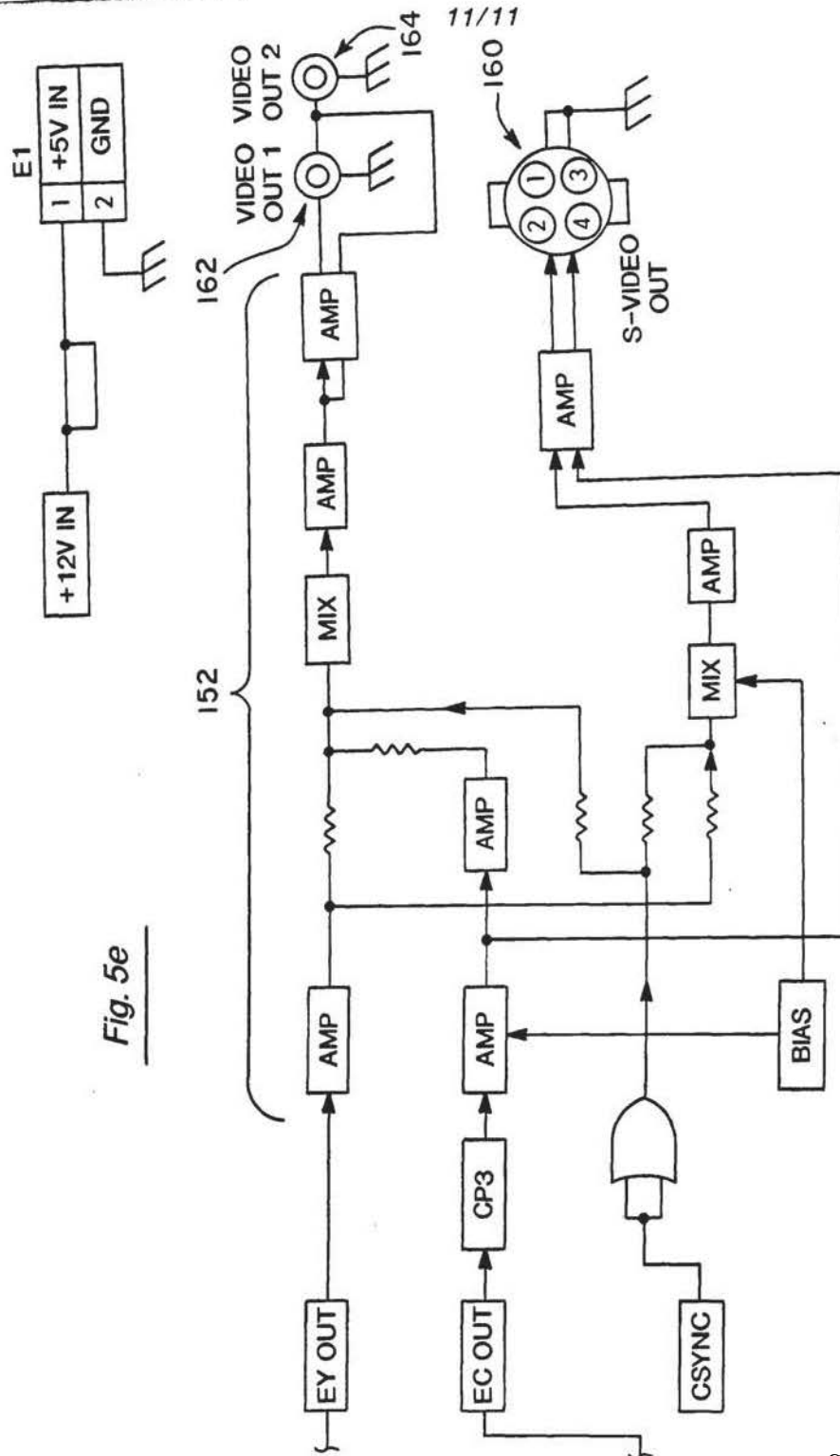
860201-5895760



860201-58954160

PRINT OF DRAWINGS  
AS ORIGINALLY FILED

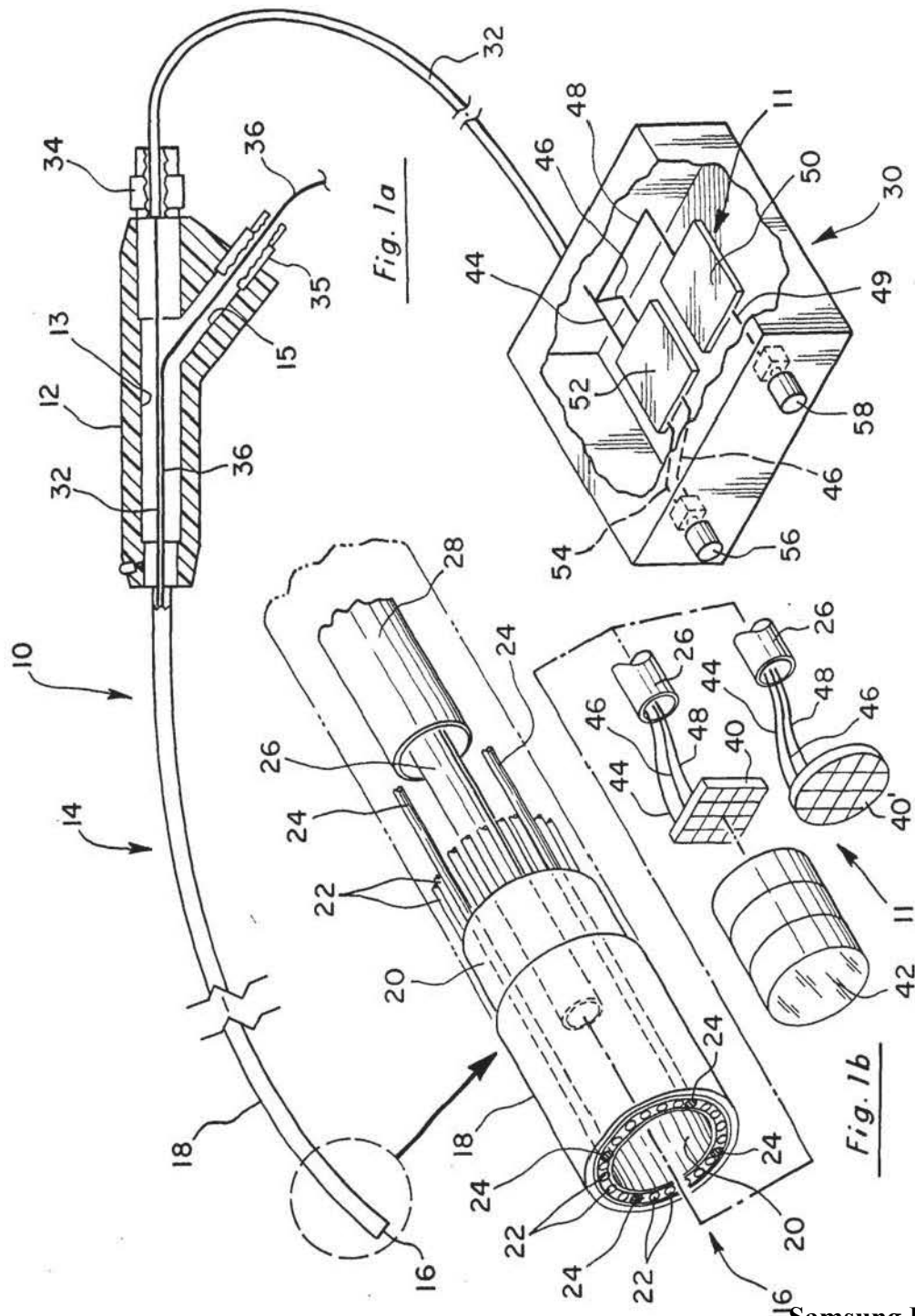
Fig. 5e



6043839

1/11

860201-5895/T60



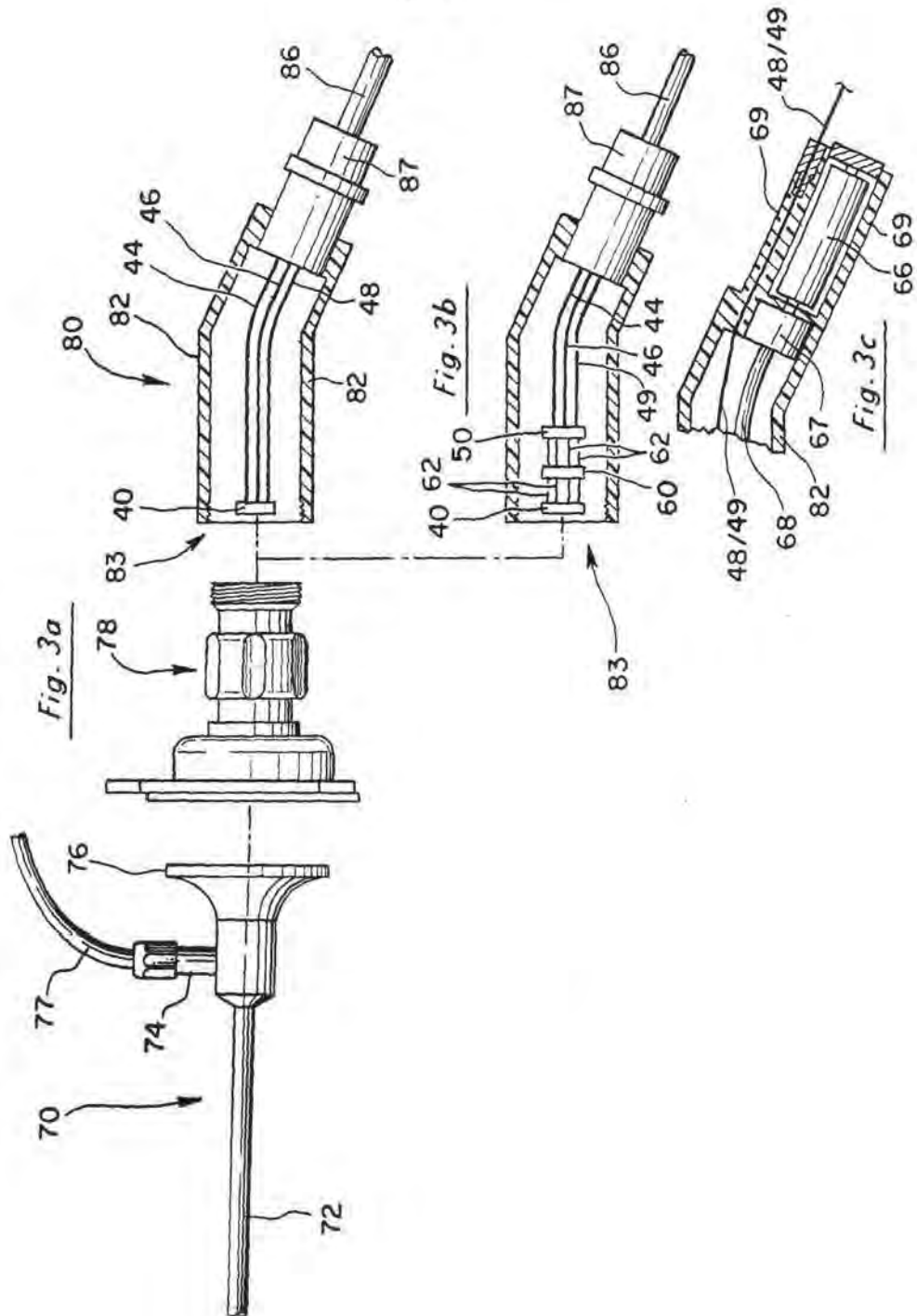




|           |                |
|-----------|----------------|
| APPROVED  | (13) FIG.      |
| BY        | CLASS SUBCLASS |
| DRAFTSMAN |                |

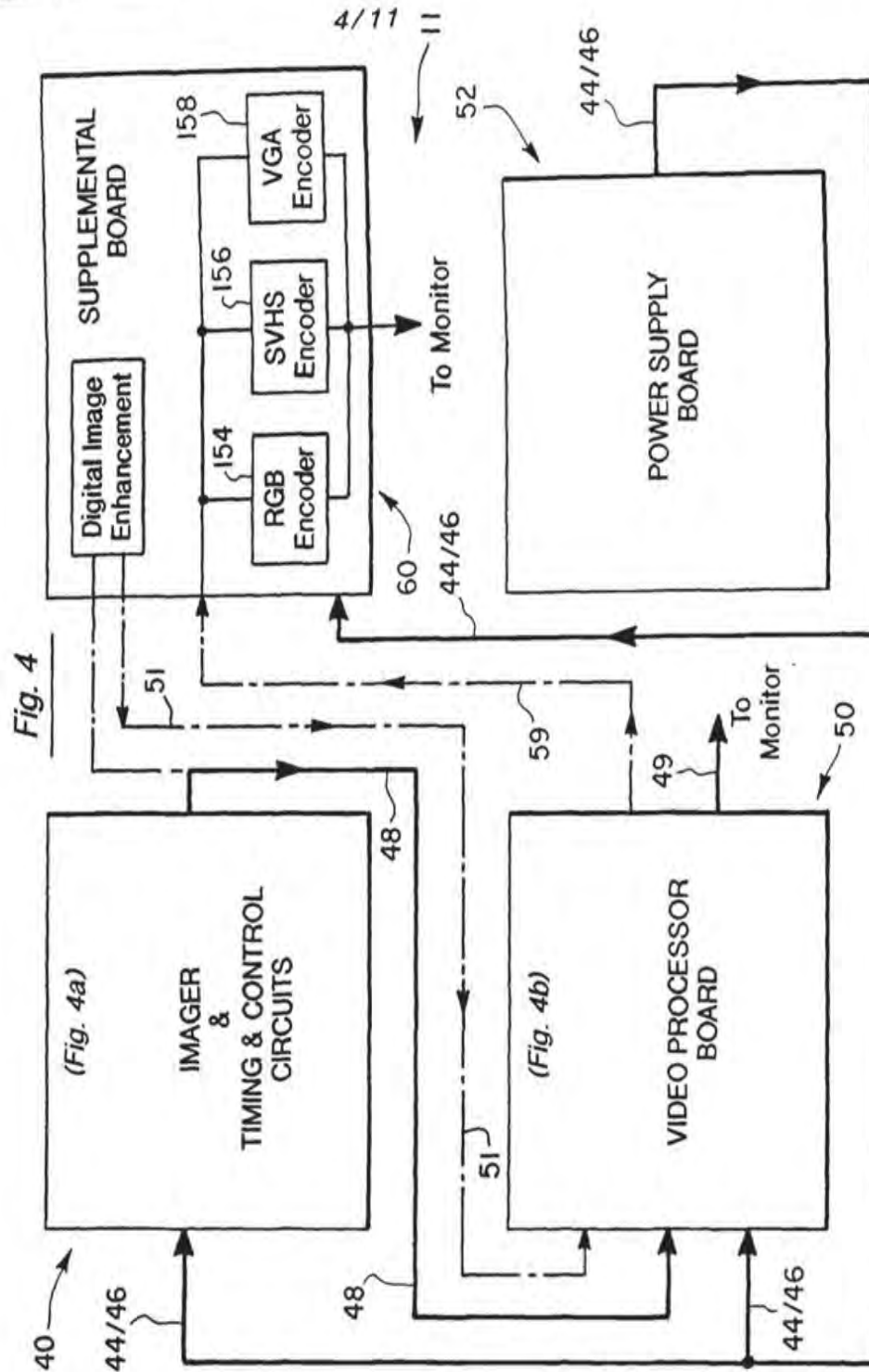
3/11

860201-58954F60

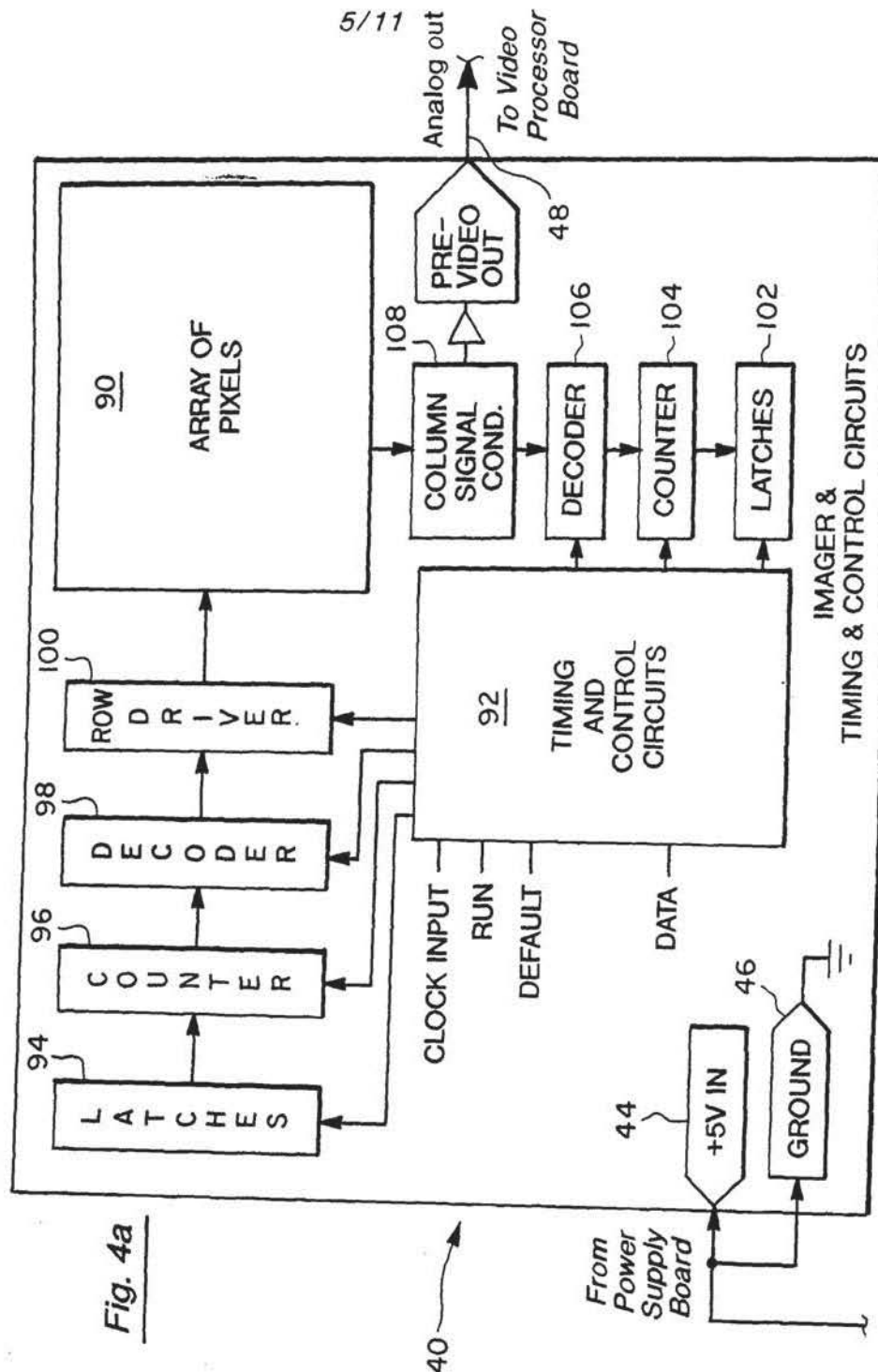


|           |           |          |
|-----------|-----------|----------|
| APPROVED  | O.G. FIG. |          |
| BY        | CLASS     | SUBCLASS |
| DRAFTSMAN |           |          |

09175685.102098



|           |            |          |
|-----------|------------|----------|
| APPROVED  | O. L. FIG. |          |
| BY        | CLASS      | SUBCLASS |
| DRAFTSMAN |            |          |



|           |           |          |
|-----------|-----------|----------|
| APPROVED  | O.G. FIG. |          |
| BY        | CLASS     | SUBCLASS |
| DRAFTSMAN |           |          |

6/11

860201-58957160

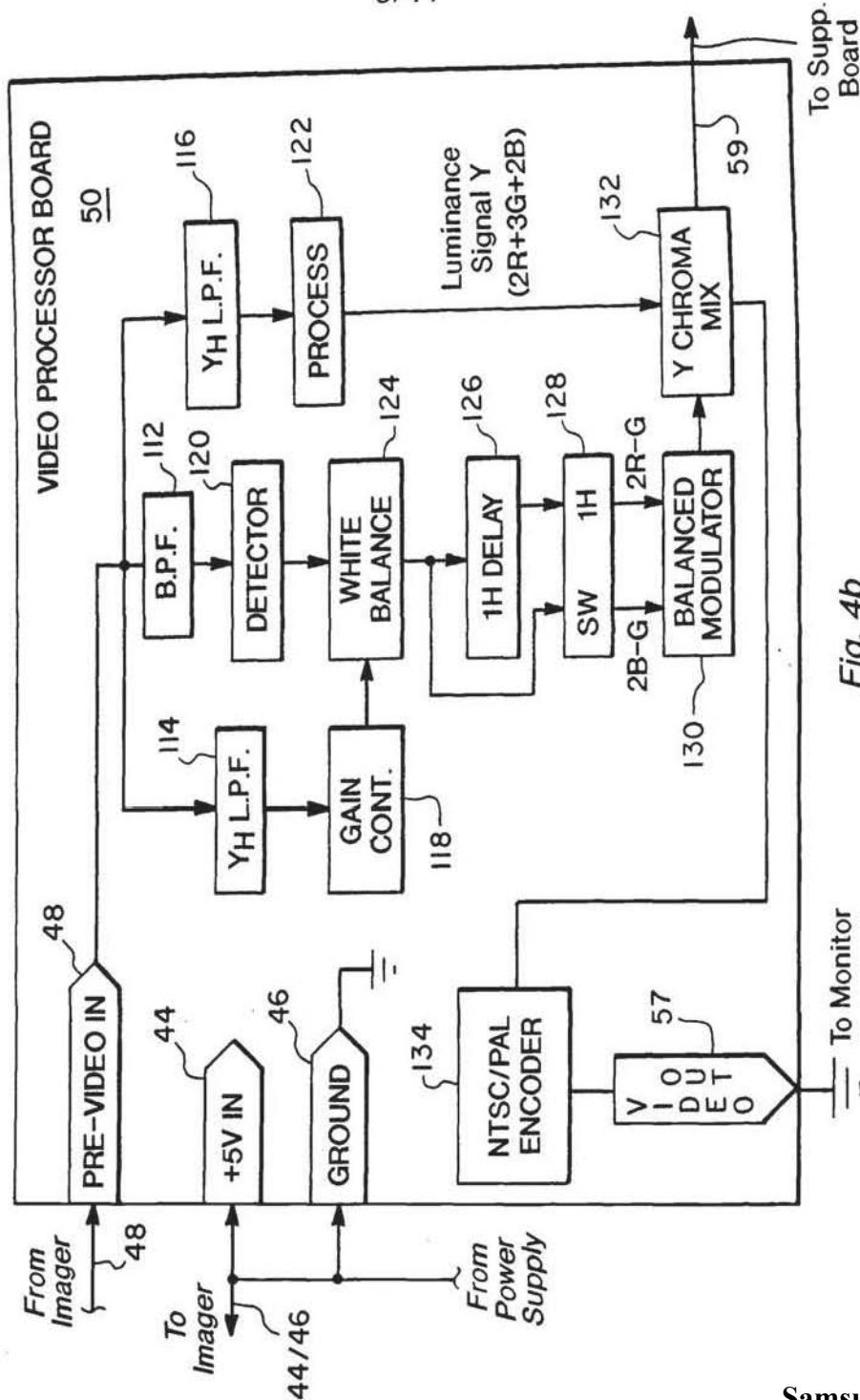
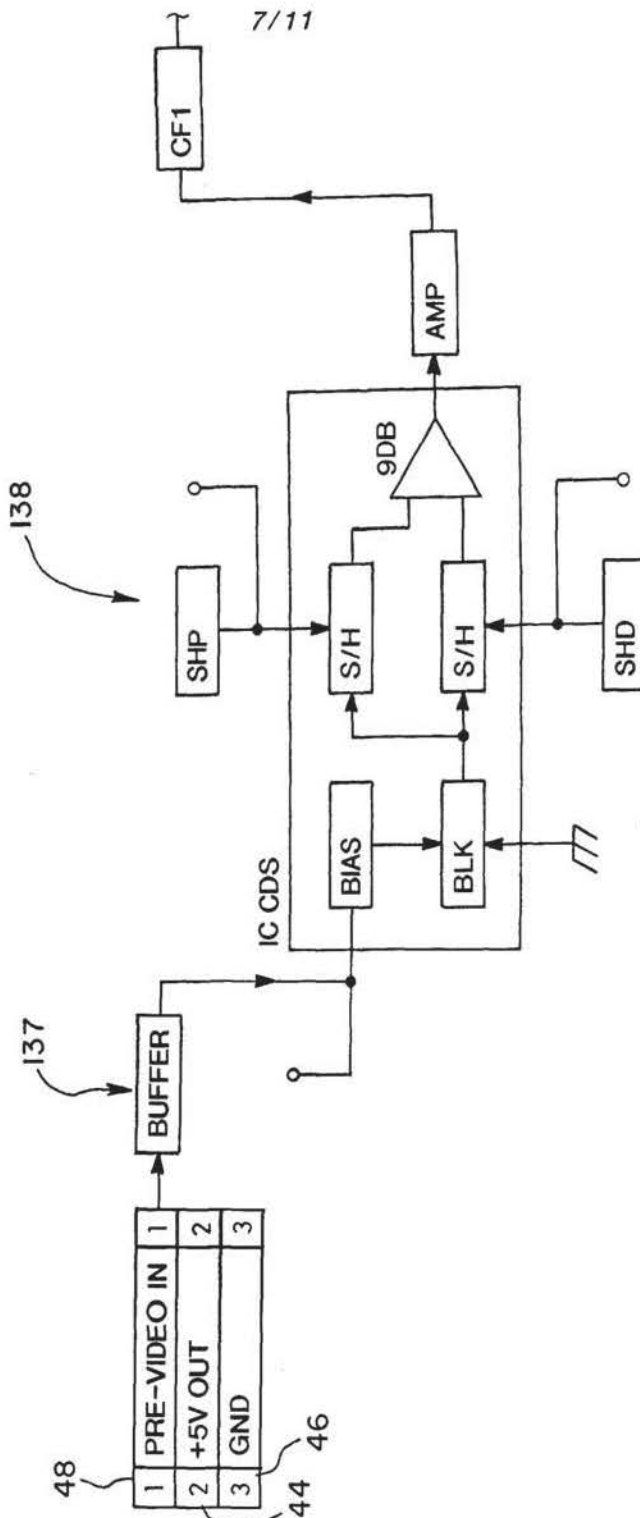


Fig. 4b

|           |                |
|-----------|----------------|
| APPROVED  | O.G. FIG.      |
| BY        | CLASS SUBCLASS |
| DRAFTSMAN |                |

86020T-5895/T60

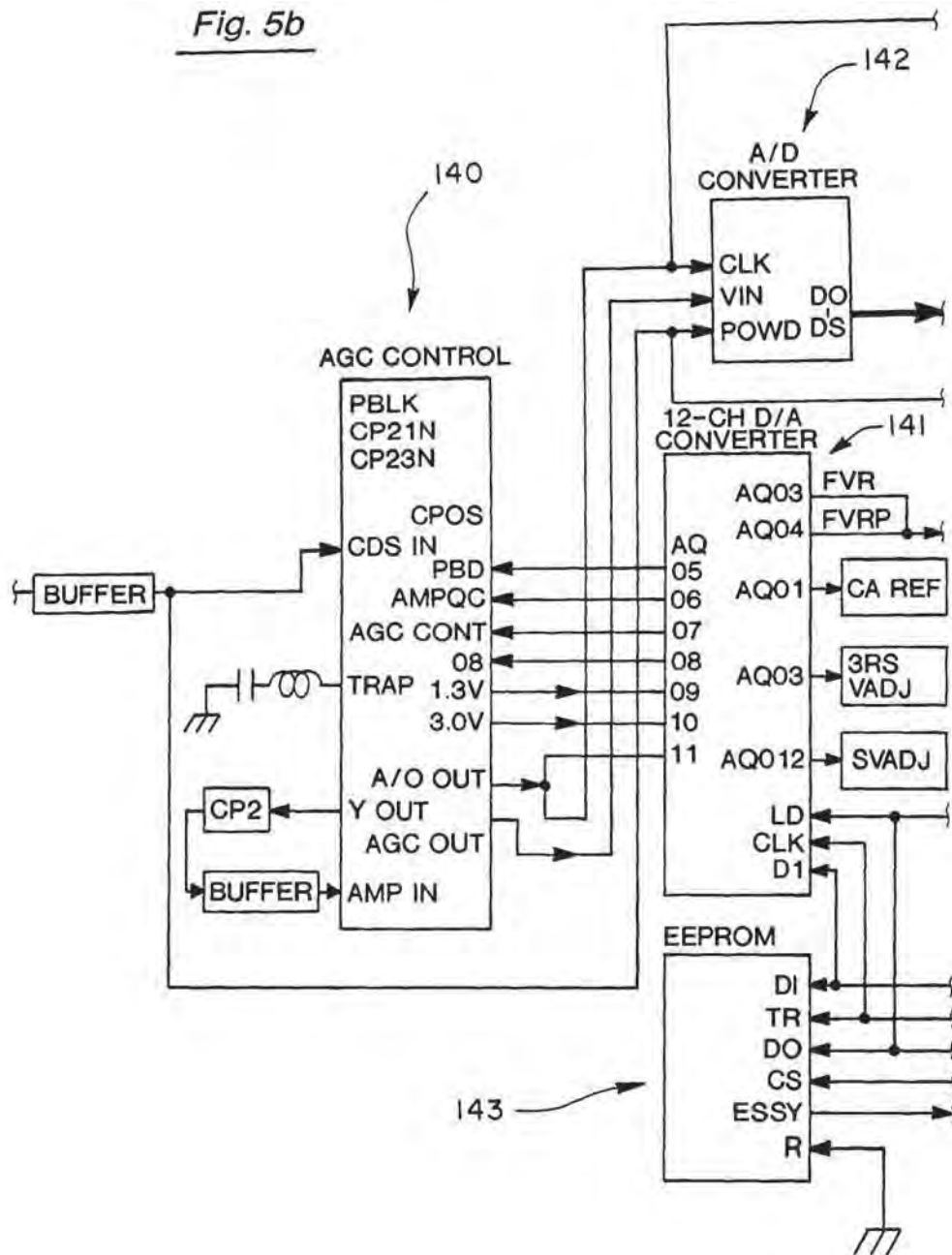
Fig. 5a



|           |           |
|-----------|-----------|
| APPROVED  | O.G. FIG. |
| CLASS     | SUBCLASS  |
| DRAFTSMAN |           |

8/11

Fig. 5b

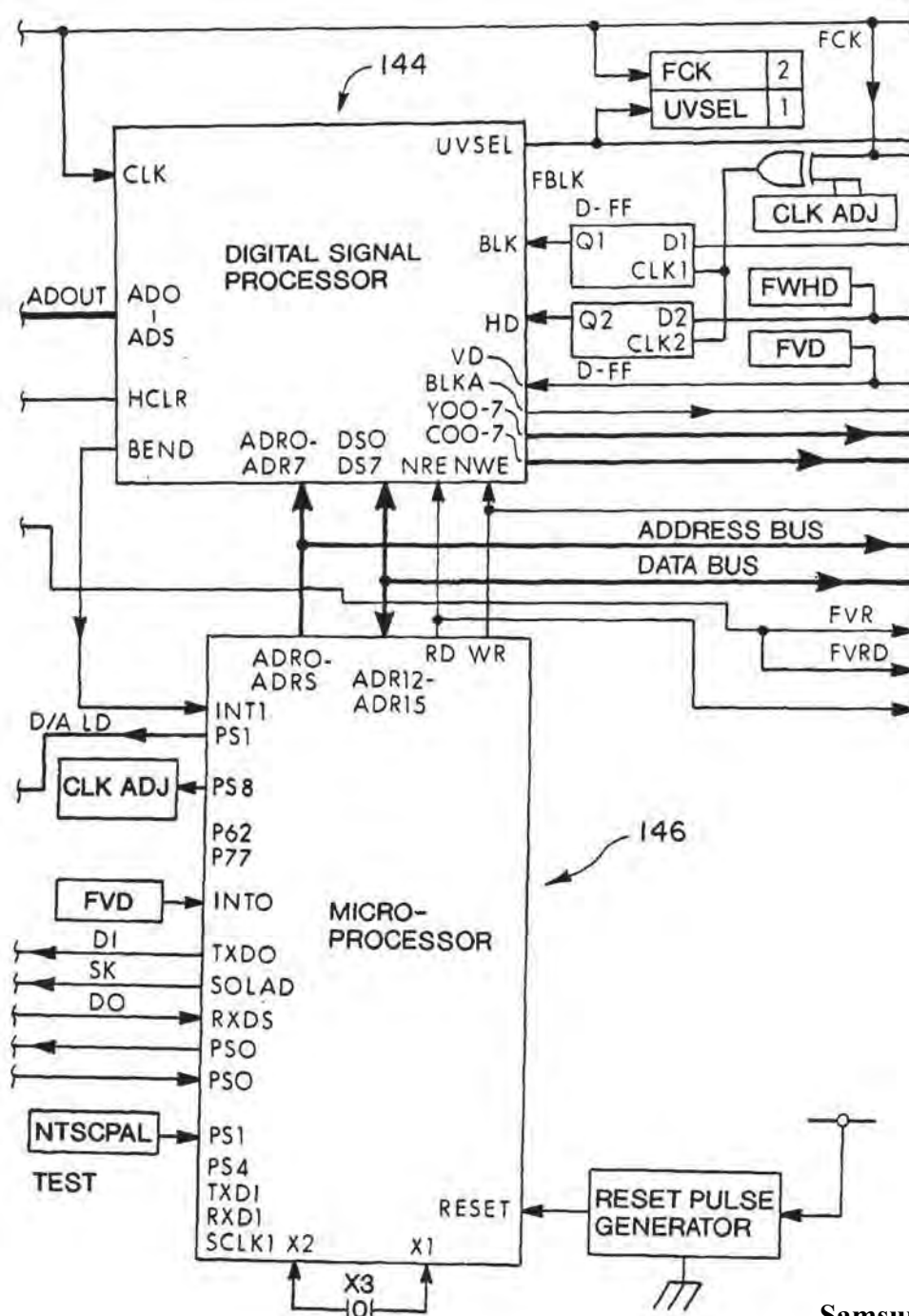


09175685-102098

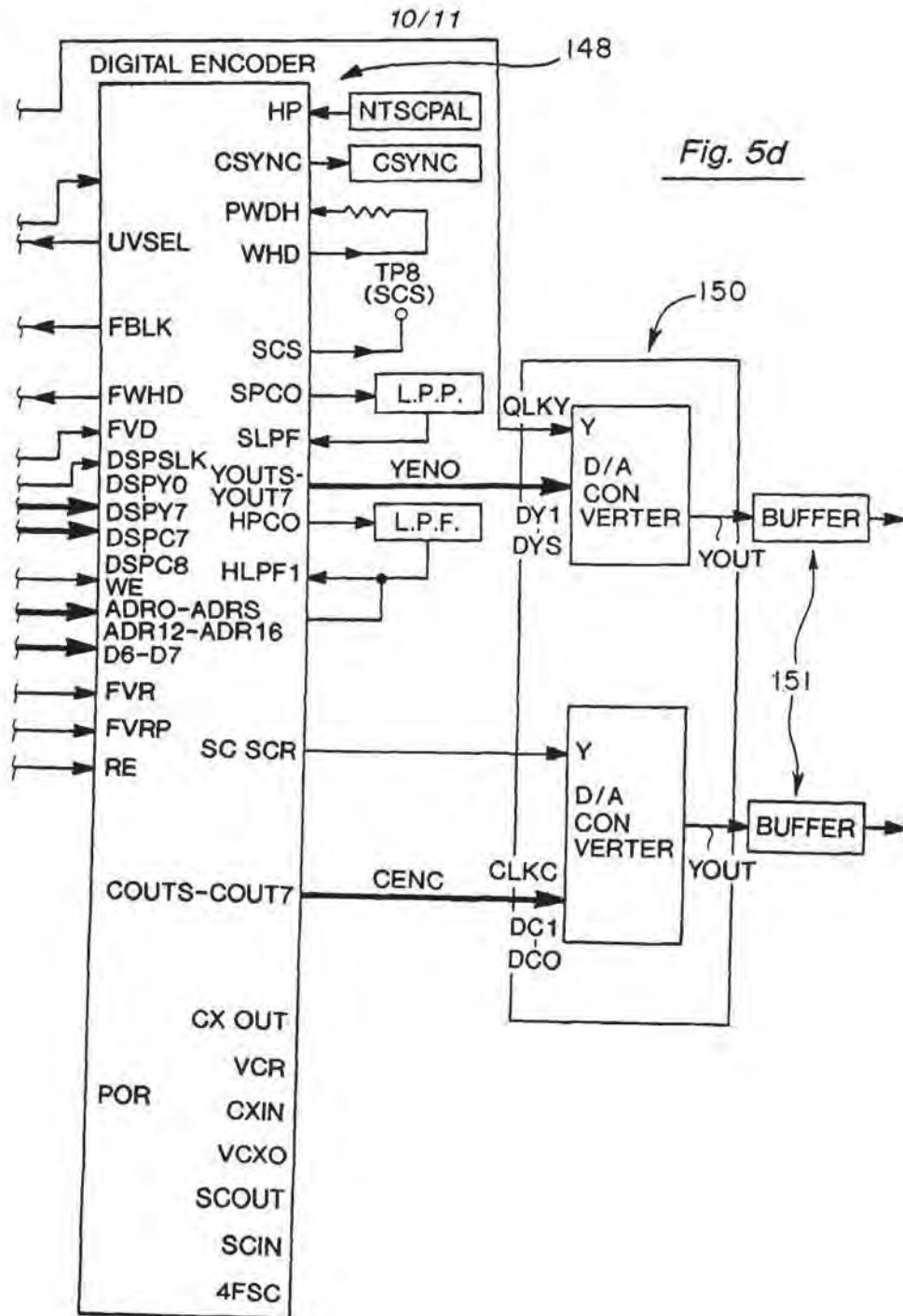
|           |                |
|-----------|----------------|
| APPROVED  | O.G. FIG.      |
| BY        | CLASS SUBCLASS |
| DRAFTSMAN |                |

9/11 Fig. 5c

0475685, 102098

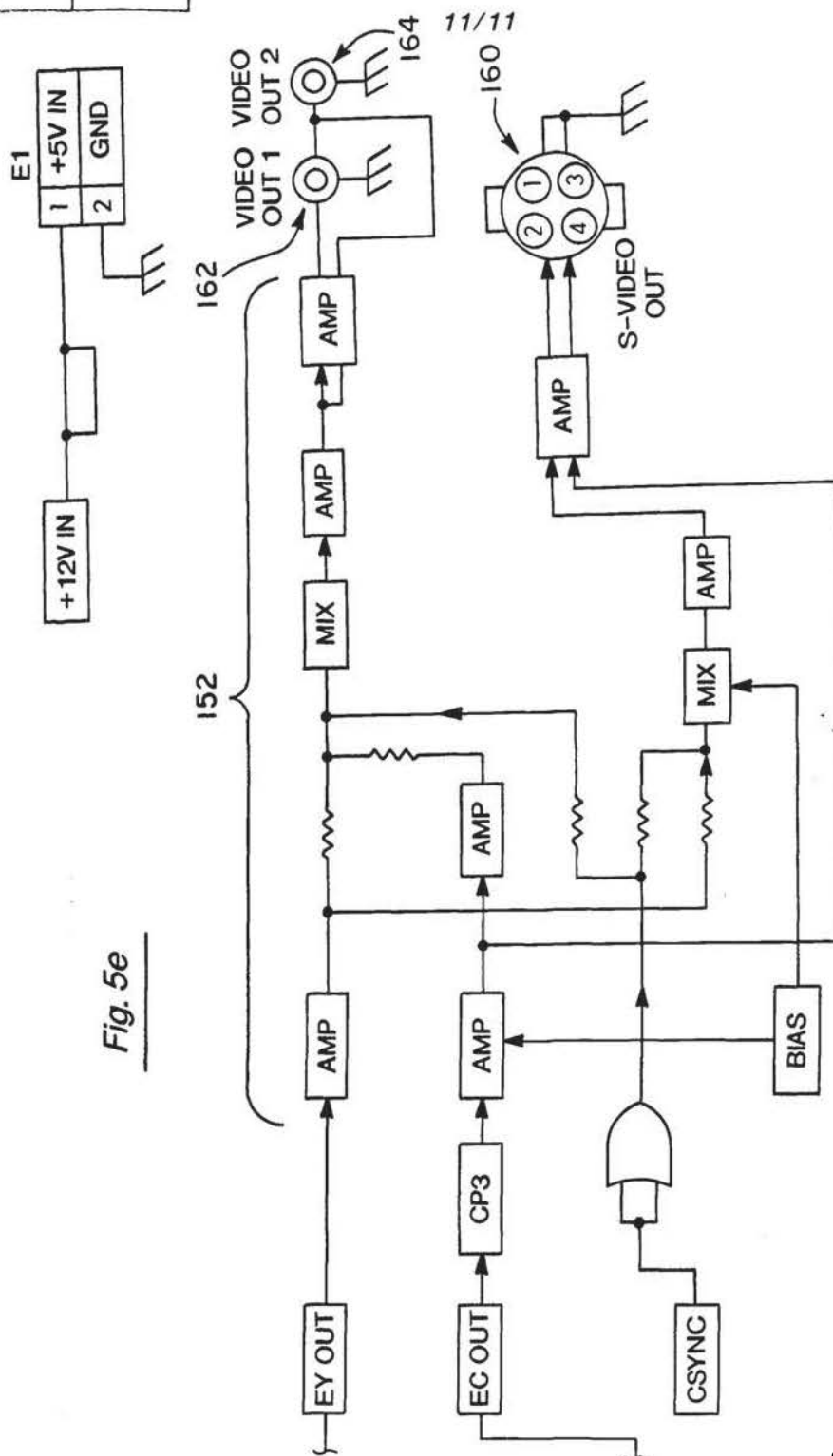






|           |           |          |
|-----------|-----------|----------|
| APPROVED  | O.G. FIG. |          |
| BY        | CLASS     | SUBCLASS |
| DRAFTSMAN |           |          |

09175685.102098



1012003/127UB  
K. P. M. W. B.

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

PTO/SB/21 (6-98)  
Approved for use through 09/30/2000. OMB 0651-0031  
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 displays a valid OMB control number.



# TRANSMITTAL FORM

to be used for all correspondence after initial filing)

Total Number of Pages in This Submission 283

|                        |                           |
|------------------------|---------------------------|
| Application Number     | 09/175,685                |
| Filing Date            | 10/20/98                  |
| First Named Inventor   | Edwin L. Adair, et al.    |
| Group Art Unit         | RECEIVED                  |
| Examiner Name          | FEB 25 1999               |
| Attorney Docket Number | E97-13 CIP2<br>GROUP 2700 |

## ENCLOSURES (check all that apply)

- ☐ Fee Transmittal Form
- ☐ Fee Attached
- ☐ Amendment / Response
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
- ☐ Extension of Time Request
- ☐ Express Abandonment Request
- ☒ Information Disclosure Statement
- ☐ Certified Copy of Priority Document(s)
- ☐ Response to Missing Parts/Incomplete Application
- ☐ Response to Missing Parts under 37 CFR 1.52 or 1.53

- ☐ Assignment Papers (for an Application)
- ☐ Drawing(s)
- ☐ Licensing-related Papers
- ☐ Petition Routing Slip (PTO/SB/69) and Accompanying Petition
- ☐ Petition to Convert to a Provisional Application
- ☐ Power of Attorney, Revocation Change of Correspondence Address
- ☐ Terminal Disclaimer
- ☐ Small Entity Statement
- ☐ Request for Refund

- ☐ After Allowance Communication to Group
- ☐ Appeal Communication to Board of Appeals and Interferences
- ☐ Appeal Communication to Group (Appeal Notice, Brief, Reply Brief)
- ☐ Proprietary Information
- ☐ Status Letter
- ☒ Additional Enclosure(s) (please identify below):

Copies of references cited  
Return postcard

Remarks

## SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

|                         |  |
|-------------------------|--|
| Firm or Individual name | Brent P. Johnson<br>Fields & Johnson, P.C. |
| Signature               |  |
| Date                    | 2/16/99                                    |

## CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231 on this date: 2/16/99

|                       |                  |
|-----------------------|------------------|
| Typed or printed name | Brent P. Johnson |
| Signature             |                  |
| Date                  | 2/16/99          |

Burden Hour Statement: This form is estimated to take 0.2 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: Assistant Commissioner for Patents, Washington, DC 20231.



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of

Edwin L. Adair, Jeffrey L. Adair,

Randall S. Adair

Serial No.: 09/175,685

Filed: October 20, 1998

For: "Reduced Area Imaging  
Devices"

) SUBMISSION OF  
) INFORMATION DISCLOSURE  
) CITATION

herby certify that this correspondence is being  
deposited with the United States Postal Service as  
first class mail in an envelope addressed to:  
Assistant Commissioner for Patents, Washington,

D.C. 20231, on

2/16/99  
(Date of Deposit)

*Katherine L. Anderson*  
Name of applicant, assignee, or Registered Prop.

Assistant Commissioner for Patents  
Washington, D.C. 20231

RECEIVED

FEB 25 1999

Sir:

Enclosed for the Examiner's consideration is an Information  
Disclosure Citation In An Application along with copies of each of the  
references cited. These references include all the references cited by the  
applicant or by the Patent Office in co-pending applications Serial Nos.  
08/944,322 and 08/976,976. This Information Disclosure Citation also  
includes two additional references which were cited in the International  
Search Report of a related PCT application, International Application No.  
PCT/US98/19379.

Respectfully submitted,

FIELDS & JOHNSON, P.C.

Gary D. Fields

Brent P. Johnson

Attorneys For Applicant

8480 East Orchard Road, Suite 5600

Englewood, CO 80111

(303) 689-9100

Date:

2/16/99

EXPRESS MAIL NO. EL146014919US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

JCS11 U.S. PTO  
09/175685  
10/20/98

In Re the Continuation-in-Part  
Application of

) PETITION TO MAKE  
) SPECIAL UNDER  
) 37 C.F.R. §1.102

Edwin L. Adair, Jeffrey L. Adair,  
Randall S. Adair

)  
)  
)

Corresponding to  
U.S. Serial No.: 08/944,322  
Filed: October 6, 1997

)  
)  
)  
)

For: "Reduced Area Imaging Devices")

Assistant Commissioner for Patents  
Washington, D.C. 20231

PETITION TO MAKE SPECIAL


Dear Sir\Madam:

One of the Applicant hereby petitions to make the above-identified application special under 37 C.F.R. §1.102(c). According to this rule, this petition may be filed without a fee because the basis for this petition is the Applicant's age.

Attached with this Petition is Applicant's Declaration indicating that Applicant is 65 years of age, or older.

Respectfully submitted,

FIELDS & JOHNSON, P.C.

  
\_\_\_\_\_

Gary D. Fields

Brent P. Johnson

Attorneys for Applicant

8480 East Orchard Road, Suite 5600

Englewood, CO 80111

(303) 689-9100

Date: 10/20/98

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE



In Re the Continuation in Part ) **DECLARATION UNDER**  
Application of ) **37 C.F.R. § 1.102**  
)  
Edwin L. Adair, Jeffrey L. Adair, )  
Randall S. Adair )  
)  
Corresponding to )  
U.S. Serial No. 08/944,322 )  
Filed: October 6, 1997 )  
)  
For: "Reduced Area Imaging Devices" )

Assistant Commissioner for Patents  
Washington, D.C. 20231

**DECLARATION OF EDWIN L. ADAIR**

I, Edwin L. Adair, hereby declare that, as of the filing date of the above-identified application, I am 65 years of age or older.

I further declare under penalty of perjury pursuant to the laws of the United States of America that the foregoing is true and correct, and that this Declaration was executed by me on 10/20, 1998.

Respectfully submitted,

  
\_\_\_\_\_  
Edwin L. Adair