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PRESENT STATUS AND FUTURE PROSPECTS FOR FUJI ELECTRIC'S PHOTOCONDUCTORS

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1. INTRODUCTION

In recent years, the market for Plain Paper Copying machines (PPCs) and Printers using an electrophotographic process has grown due to advantages of high resolution, high speed and low noise. A photoconductor is the heart of the electrophotographic process. Fuji Electric first developed a Se/Te photoconductor and placed it on the market in 1973. Next, we developed a Se/As photoconductor with high sensitivity and high durability, and have further expanded the market. In recent years, we have commercialized an organic photoconductor (OPC) with remarkably improved properties to complete our line of product models (see *Fig. 1*).

Table 1 shows the types of Fuji Electric's photoconductors and their applications. Selecting an optimum photoconductor for the PPC and the printer depends on the charging polarity of the photoconductor and the light source wavelength of the PPC and the printer. Generally, the charging polarity of selenium photoconductors is positive and that of organic photoconductors is negative.

Fig. 1 Fuji Electric's photoconductors

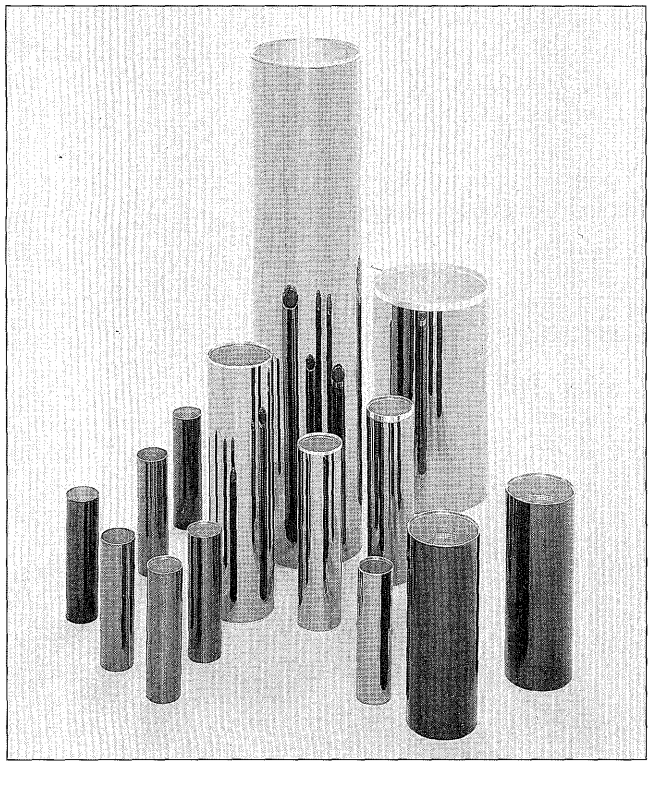


Table 1 Types of Fuji Electric's photoconductor and their applications

Application (Light source)	Type	4	5	8	9B
	Material	Se/Te	$As_2 Se_3$	Organic	Organic
	Polarity	+	+	–	–
PPC (White light)	medium- and low-speed	○			○
	medium- and high-speed		○		○
Printer (LD/LED He-Ne Laser)	medium- and low-speed	○			○
	medium- and high-speed		○	○	
Facsimile (LD/LED)		○		○	
Digital Copying Machine (LD/LED)		○		○	
Plotter (LD/LED)			○	○	

Fig. 2 Continuous mass production line

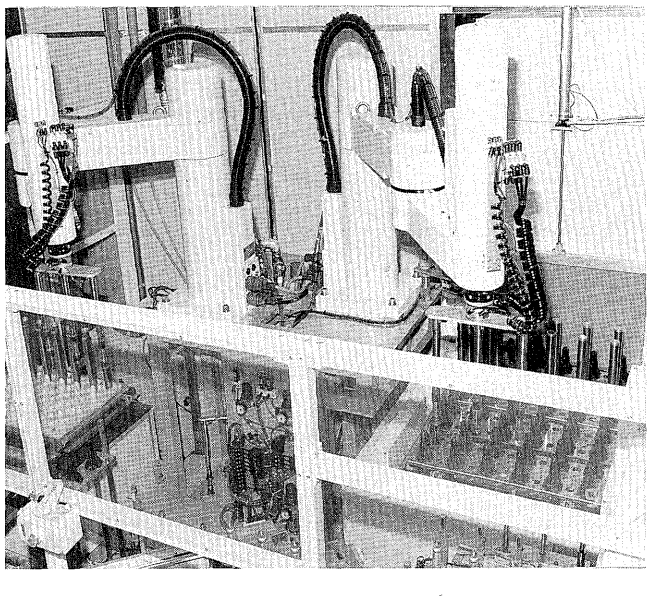


Fig. 3 Double layer in which each layer has its own function

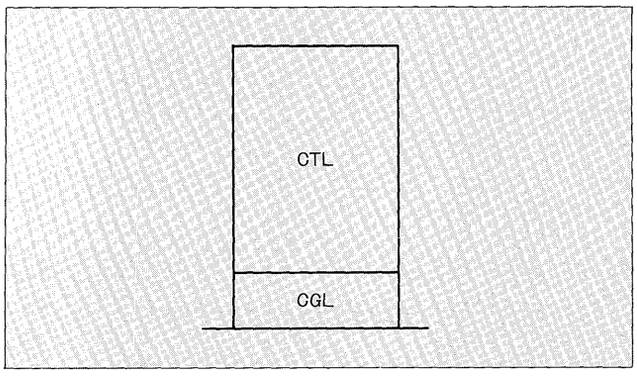


Table 2 Layer structure and application of Fuji Electric's OPC

Type	Layer structure		Application
	CGL	CTL	
8B	Phthalocyanine Pigment + Binder	Binder + Hydrazone	medium- and high-speed printers
8D	Phthalocyanine Pigment + Binder	Polymer	Liquid Toner Development
9B	Azo Pigment + Binder	Binder + Hydrazone	PPCs

Each type of photoconductor has its own spectral sensitivity, which should match the light source. Typical sizes of the photoconductor are 30 through 260 mm in diameter and 230 through 1,000 mm in length.

2. ORGANIC PHOTOCONDUCTOR (OPC)

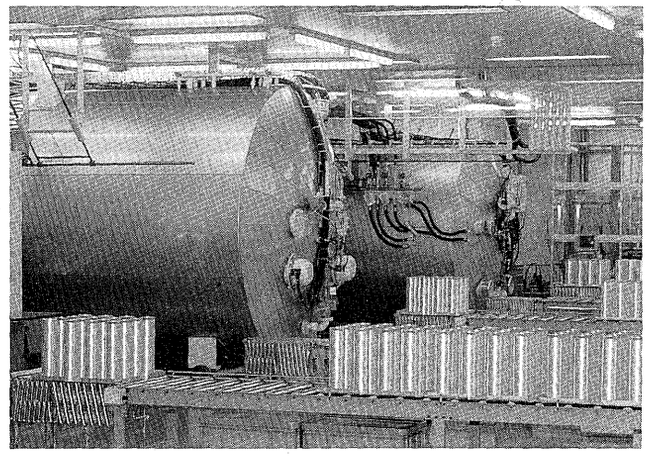
The OPC is manufactured by the dipping method and/or the spray method, both of which are suitable for continuous mass production (see *Fig. 2*). The OPC is composed of a double layer in which each layer has its own function (see *Fig. 3*). A carrier generation layer (CGL) which is approximately 1 μm thick generates electric holes during exposure. A carrier transport layer (CTL), normally 20 μm thick, transports the carriers generated in CGL to the surface of CTL. *Table 2* shows the layer structure of Fuji Electric's OPCs and their applications. Type 8B and Type 8D have spectral sensitivity in the infrared region (600 through 800 nm), while Type 9B is in the visible region (400 through 600 nm). The CTL of Type 8B and Type 9B consists of a wear resistant binder and Carrier Transport Materials (CTM). The Type 8D CTL, which is a single polymer, is resistant to both solvents and wear, and has carrier transport functionality. The Type 8D is the first OPC designed for use in a liquid development system.

The OPC may be designed from a variety of materials. For this reason Fuji Electric has studied many kinds of new chemicals. Needless to say, safety is one of our most important test items. The safety of our OPC has been thoroughly verified by the authorized evaluating institution.

Table 3 Line of Fuji Electric's selenium photoconductors and their applications

Type	Material	Layer structure		Application
4C	Se/Te	CGL + CTL		Medium- and Low-speed PPCs
4D	Se/Te	OCL + CGL + CTL		Laser Diode Printers
5	As_2Se_3	Monolayer	Mirror surface	High-speed PPCs He-Ne Line Printers Light Emitting Diode Printers
5B	As_2Se_3	Monolayer	Rough surface	
5E	As_2Se_3	Monolayer + Doping	Mirror surface	
5F	As_2Se_3	Monolayer + Doping	Rough surface	

Fig. 4 Coating equipment for vacuum evaporation



3. SELENIUM PHOTOCONDUCTOR

Selenium photoconductors created the photoconductor market by putting the electrophotographic process invented by C.F. Carlson into use. *Table 3* shows the line of Fuji Electric's selenium photoconductors and their applications. A selenium layer of a few 10 μm is coated on an aluminum tube by evaporation (see *Fig. 4*).

Type 4C consists of a CGL, which is a film of comparatively high concentration Te, and a CTL. Sufficient sensitivity and durability for the PPCs were obtained by increasing the thickness of CGL to greater than 5 μm.

Type 4D is highly sensitive to a laser diode, and consists of a CGL which is very thin film (less than 0.2 μm) of high concentration Te, a CTL and an OCL (Over Coat Layer) which is added to enhance durability. Type 4D was developed mainly for medium-speed printers. The composition profile of each layer requires precise control of the concentration during the manufacturing process.

Type 5 is a monolayer photoconductor. It is classified into four types: 5, 5B, 5E and 5F. They differ in surface treatment and presence of doped impurities. Type 5 is applicable to the ultrahigh-speed line printers (more than 15,000 lines/min) as well as the high-speed PPCs.

4. AFTERWORD

The progress in dispersive treatment technology due to computer down sizing, and increases in imaging speed made possibly by highly integrated circuits, are the main factors behind the growth of electrophotographic photoconductors. Further progress in hard printing technology, including higher resolution and greater reliability is expected as digital and color image technology advances. Though use of ink jet printing using special paper will expand in low-speed printer applications, as well as electrophotographic printing, both are expected to coexist.

Photoconductors are a consumption item. Environmental protection concerns make it very important to develop a recycling system in the future.

The photoconductor market will grow even more with these trends. Fuji Electric will continue to make efforts to develop photoconductors of high quality and high reliability while at the same time anticipating the needs of the market.