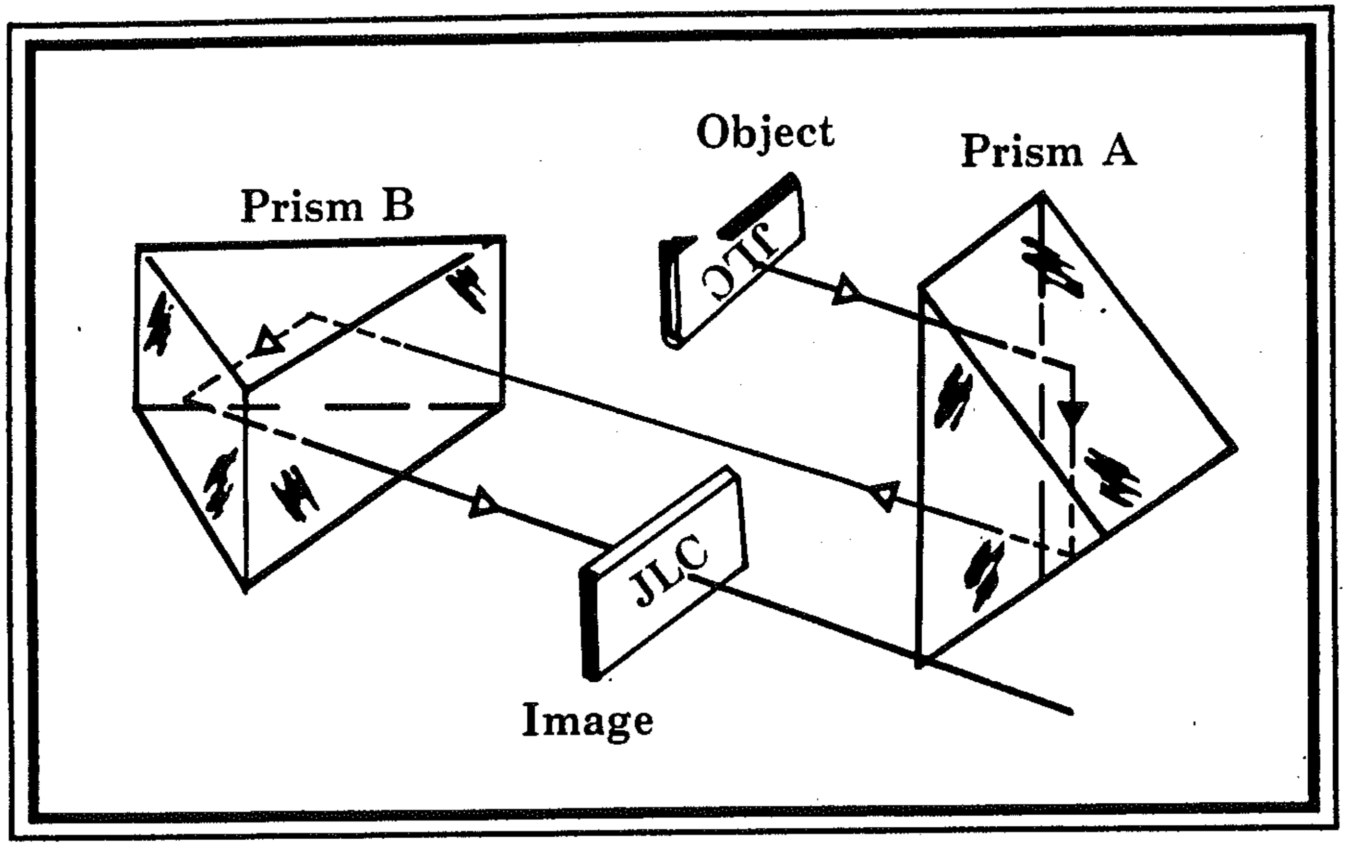
JOINT LOGISTICS COMMANDERS

PRECISION OPTICS STUDY

19 JUNE 1987



PREPARED BY

THE JOINT PRECISION OPTICS
TECHNICAL GROUP
OF
THE JOINT GROUP
ON THE INDUSTRIAL BASE

Joint Logistics Commanders Precision Optics Study

Prepared by

U.S. Department of Commerce
Bureau of Export Administration
Office of Strategic Industries and Economic Security
Strategic Analysis Division

19 June 1987

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Joint Logistics Commanders, Precision Optics Study - Written by the Joint Precision Optics Technical Group chartered under the Joint Logistics Commanders, this report assesses the precision optics industry based on surveys of U.S. producers. The report finds a shortfall in domestic production capacity to meet mobilization requirements and concludes that this shortfall presents a threat to national security in time of emergency. Concern is also expressed about the continued availability of optical glass. The report concludes that the underlying cause of the shortfall is the lack of international competitiveness on the part of U.S. firms and recommends that procurement of certain items be restricted to domestic companies in order to maintain a mobilization base.

FINAL REPORT

JOINT PRECISION OPTICS TECHNICAL GROUP

ROBERT P. O'SHAUGHNESSY, ET AL.

JUNE 1987

Special Acknowledgement - The Chairman of the Joint Precision Optics Technical Group of the Joint Group on Industrial Base wishes to express his deep gratitude for the support given to this study by the Office of Industrial Resource Administration (OIRA) of the Department of Commerce. The data collected and analyzed by the OIRA formed the major basis from which the conclusions were drawn. Also appreciated was the administrative assistance in the formulation of this report.

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ERRATA

Page 37	Line 35: Change "Fujitsu" to "Fujinan"
Page 51	Lines 5 to 7: Replace sentence beginning "The work ethic..." with "Efficient work patterns may not be as developed in countries like Singapore and China as they are in Japan and the United States."

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JOINT PRECISION OPTICS TECHNICAL GROUP

LIST OF MEMBERS

NAME	ORGANIZATION
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1. EXECUTIVE SUMMARY

1.1 OVERVIEW

The Joint Precision Optics Technical Group (JPOTG) was chartered under the Joint Group on Industrial Base (JGIB) of the Joint Logistics Commanders (JLC) to perform the following tasks:

a. Identify the Military Services' projected peacetime, surge and mobilization requirements for Precision Optics.

b. Identify projected requirements for Strategic Defense Initiative (SDI) Optics.

c. Assess the capability of the U.S. Precision Optics Base to provide for these requirements.

d. Assess the degree of erosion in capability that has occurred because of foreign competition.

e. Prepare recommendations to eliminate any production shortfalls which may be identified.

As part of the JPOTG study effort, the Department of Commerce, Office of Industrial Resource Administration, surveyed U.S. Precision Optics and Optical Material producers under mandatory authority of the Defense Production Act of 1950, as amended. Plant visits were also conducted by the study team to enhance the survey questionnaire data.

1.2 MAJOR FINDINGS

1.2.1 Requirements for Optics

In peacetime, the Services require approximately 100,000 optical components per month of the types used for direct application in military systems. Mobilization requirements were found to be much greater.

1.2.2 Domestic Production Capacity

Domestic production capacity (defense and non-defense) totalled about 316 thousand components per month in 1985, down considerably from previous years. Defense production capacity was estimated to be 87 thousand components per month, or approximately 28 percent of the overall total. The industry operated at 60 percent of capacity in 1985 and according to survey responses would require 43 weeks to reach full capacity production levels. This extended "ramp-up" period is caused by shortages of skilled opticians and long lead times for raw materials. Capacity utilization fell below 60 percent in 1986 as production is estimated to have dropped by over 20 percent from 1985 levels.

The potential of converting commercial production capacity to military production appears inadequate to support the rapid increase in optical elements needed to meet emergency defense requirements. To effectively convert capacity to military production, the skill level of many opticians would need to be enhanced and additional specialized equipment would have to be installed. One firm indicated conversion could take a year or more to accomplish. Thus, a significant shortfall exists in the capacity of the domestic industry to meet the needs of the services for mobilization.

1.2.3 Status of Domestic Raw Glass Sector

Foreign competition has reduced the number of domestic optical glass producers to a single firm. Seventy percent of the glass used by U.S. component producers is now imported and this percentage is expected to increase in the near future. In addition, the breadth of the domestic raw optical glass market has declined sharply as the production of lenses, prisms and other end-items that use optical glass has migrated offshore. The loss of this firm's highly specialized glass blending and melting capabilities could not be easily replaced and would make U.S. optical component firms totally dependent on foreign sources.

1.2.4 Status of Domestic Optical Element Sector

The U.S. optical element sector as a whole is in serious decline. Nearly all domestic commercial optical element production has been displaced by offshore producers. The trend in defense procurement is to increasingly buy foreign made optics, primarily because of their lower cost. Imported optical components currently account for over 98 percent of total U.S. consumption. In 1986, imports accounted for approximately 50 percent of DOD consumption. Overall employment declined from 3,096 in 1981 to only 1,655 in 1986. Further declines are expected. The employment of opticians who are critical to the production process has declined by over 40 percent since 1981.

1.2.5 Foreign Dependency

Most optical companies are reliant to some degree on imports of materials, parts, and/or production equipment. This reliance has grown in recent years in reaction to severe international pricing pressures that have forced domestic firms to seek lower cost foreign alternatives. Every phase of the business from raw glass to finished optical systems has been impacted. Almost 70 percent of optical glass consumption was imported in 1985, primarily because of lower prices. Some optical element firms have established production plants in lower cost foreign countries. Nearly all firms are purchasing foreign made production equipment because of its reportedly better quality, lower prices and/or lack of an adequate domestic source. Moreover, foreign sourcing and dependencies can be expected to increase in the future.

1.3 MAJOR CONCLUSIONS

1.3.1 Surge and Mobilization Posture

Surge requirements were not calculated by the individual Services. Surge production "targets", however, were defined for each production plant as a doubling of its 1985 defense production in a six month period, while maintaining non-defense production at peacetime levels. The surveyed firms reported they could increase defense production by 47 percent by the end of a six-month period under these conditions. Major constraints to a surge mentioned by the firms included the availability of raw materials, specialized equipment and trained opticians.

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The shortfall in production capacity to meet mobilization requirements presents a threat to national security in time of emergency. A major factor of this shortfall is the declining number of trained opticians. Because of the continuing downward trend in production capacity and the declining employment of opticians, the mobilization capability of the precision optics industry will most likely worsen in the near future. Another major concern is the continued availability of optical glass. If the sole remaining U.S. producer is forced out of business because of increasing foreign competition and declining domestic demand, the severity of the problem could increase dramatically.

The industry's collective judgement may be overly pessimistic. Consideration should be given to the idea that when faced with an actual emergency, specifications and testing procedures could be relaxed and other ways could be found to overcome problems in converting capacity, training people and acquiring equipment. If one were to make the most optimistic estimate about mobilization capacity, the domestic industry would still lack the capacity required.

1.3.2 Domestic Industrial Outlook

Based on current trends, domestic optics firms can be expected to lose the last remaining vestiges of the already import-dominated lower value end of commercial optical component markets. American firms still competing in these markets will be forced either to exit the business altogether or to reorient themselves into the more sophisticated end of the market as many have already done. Competition in the higher priced optics categories, which include most defense applications, will continue to intensify in response to this reorientation and serve to moderate future price increases.

The Japanese are now experiencing a similar phenomenon as firms in Taiwan, South Korea and Singapore have quickly expanded their shares of the low end global optics market. In reaction to this situation, Japanese firms can be expected to challenge U.S. firms in the more sophisticated end of the market in the near future.

1.4 RECOMMENDATIONS

1.4.1 Establish a Federal Acquisition Regulation (FAR) for Precision Optical Elements and Optical Glass

In compliance with the Competition in Contracting Act, amended 10 USC 2304 (C) (3) and Executive Order 11490, the Secretary of Defense can determine that in order to maintain a mobilization base, certain items can be restricted to domestic procurement. This requires a FAR clause in the FAR supplement. Based on the findings of the Joint Precision Optics Technical Group, such a clause for Precision Optics and Optical Glass is warranted.

It is recognized that there are several disadvantages to such a restriction. The major disadvantage is that the cost of procuring optical components will increase. The percentage rise for any particular system however, may or may not be significant depending on the amount and complexity of the optics in the system. Another concern is that industry could use a restrictive clause to increase profits without making the necessary investments to modernize and enhance its capabilities. To reduce this possibility, the recommended clause is set up as a temporary one, providing the industry with a time-limited opportunity to improve its competitive position. Thus, seven years was chosen as a reasonable period for the clause, after which open competition would again take affect.

Furthermore, so as not to initially overwhelm the domestic industry with new orders, the clause should be phased in. The first two years are set aside as a necessary adjustment period with only fifty percent of optical components reserved exclusively for domestic procurement. This will give the industry time to acquire new equipment and raw material needed for increased defense production. Moreover, a two year phase-in would allow sufficient time for training additional needed opticians.

The clause should be as inclusive of the complete optical manufacturing process as possible. This will provide the basis for independent domestic capability to make optical components from the raw glass stage to the final product. Since foreign competition in optical glass production has caused a serious decline in domestically produced glass, the addition of bulk optical glass to the clause is essential to protect the production base.

It is recognized that from time to time the Service Commands will face conditions under which a waiver to this proposed FAR clause is justified. Provisions for such waivers are provided for in the clause through major command approval. Such waivers shall be in effect for only the period of time needed to permit the prime contractor to identify a domestic source of supply.

1.4.2 Review Possible Trade and Economic Remedies

The JPOTG has determined that the underlying cause of the shortfall in surge and mobilization capacity is the lack of international competitiveness on the part of U.S. firms. It did not judge the fairness of international trade, nor determine what specific measures the government could take to improve the condition of the optics sector. Many in the industry believe that the present international optics market is biased in favor of foreign firms because of strong government supports, unfair trade practices and a lack of concern by the U.S. Government. These are questions which fall primarily under the jurisdiction of the Department of Commerce. Accordingly, the second major recommendation is to request the Commerce Department to assess the trade and economic factors impacting this critical industry and formulate options to rectify the situation.

While potential policy measures designed to assist this industry may take considerable time to implement, they can be an important step toward providing a longer term solution to the competitive problems confronted by the domestic optical industry.

2. ASSESSMENT

2.1 BACKGROUND

This study is a follow-up effort to a study undertaken by the Army Materiel Command (AMC) in 1985. A detailed description of the events preceding that AMC study are presented in the final report and will not be repeated here. The important fact to note is that an earlier ('84) AD HOC study group has received JLC approval of a recommendation for a FAR clause. This proposed clause was made policy by the Under Secretary of Defense in May of 1984, but never reached full FAR status from the FAR Council. In June of 1985, the Office of the Assistant Secretary of the Army for Research, Development and Acquisition (SARDA) requested an AMC review which concluded that the Optical Industry was failing and that the need existed for FAR clause implementation. Since the AMC study dealt solely with Army requirements, it was decided to request the Joint Group on Industrial Base (JGIB) of the JLC establish the Joint Precision Optics Technical Group (JPOTG) to determine the total DOD requirements. The Department of Commerce, Office of Industrial Resource Administration was asked to participate in this assessment due to their expertise in industrial economic and trade issues.

Readers who lack a background in Optics might benefit by referring to the description of the manufacturing process for precision optics found in Appendix A.

2.2 STUDY GOALS

The goals of the JPOTG were to:

a. Identify the Military Services' projected peacetime, surge and mobilization requirements for Precision Optics.

b. Identify projected requirements for Strategic Defense Initiative (SDI) Optics.

c. Assess the capability of the U.S. Precision Optics Base to provide for these requirements.

d. Assess the degree of erosion in capability that has occurred because of foreign competition.

e. Prepare recommendations to eliminate production shortfalls.

2.3 STUDY METHODS

2.3.1 Requirements of the Services and SDI

Individual command members of the JPOTG sent requests to their subordinate agencies responsible for the acquisition of systems using optics. Counts were made of the quantity of optical elements per system; then using the number of systems required, requirements were calculated. Emphasis was placed on those items on the Critical Items List (CIL). Peacetime requirements were determined by the President's Budget for the years through 1991.

Meetings were also held at the SDIO in an effort to determine its projected requirements.

2.3.2 Industry Surveys

The Group prepared and released through the Department of Commerce, Office of Industrial Resource Administration, two in-depth industry surveys under mandatory authority of the Defense Production Act of 1950, as amended. One survey dealt with the capacity of precision optics producers to manufacture optical components. The other survey addressed producers of optical material used in both the visible (optical glass) and the infrared (germanium, etc.) ranges. (Copies of the survey instruments are attached at Appendix B.)

2.4 STUDY RESULTS AND FINDINGS

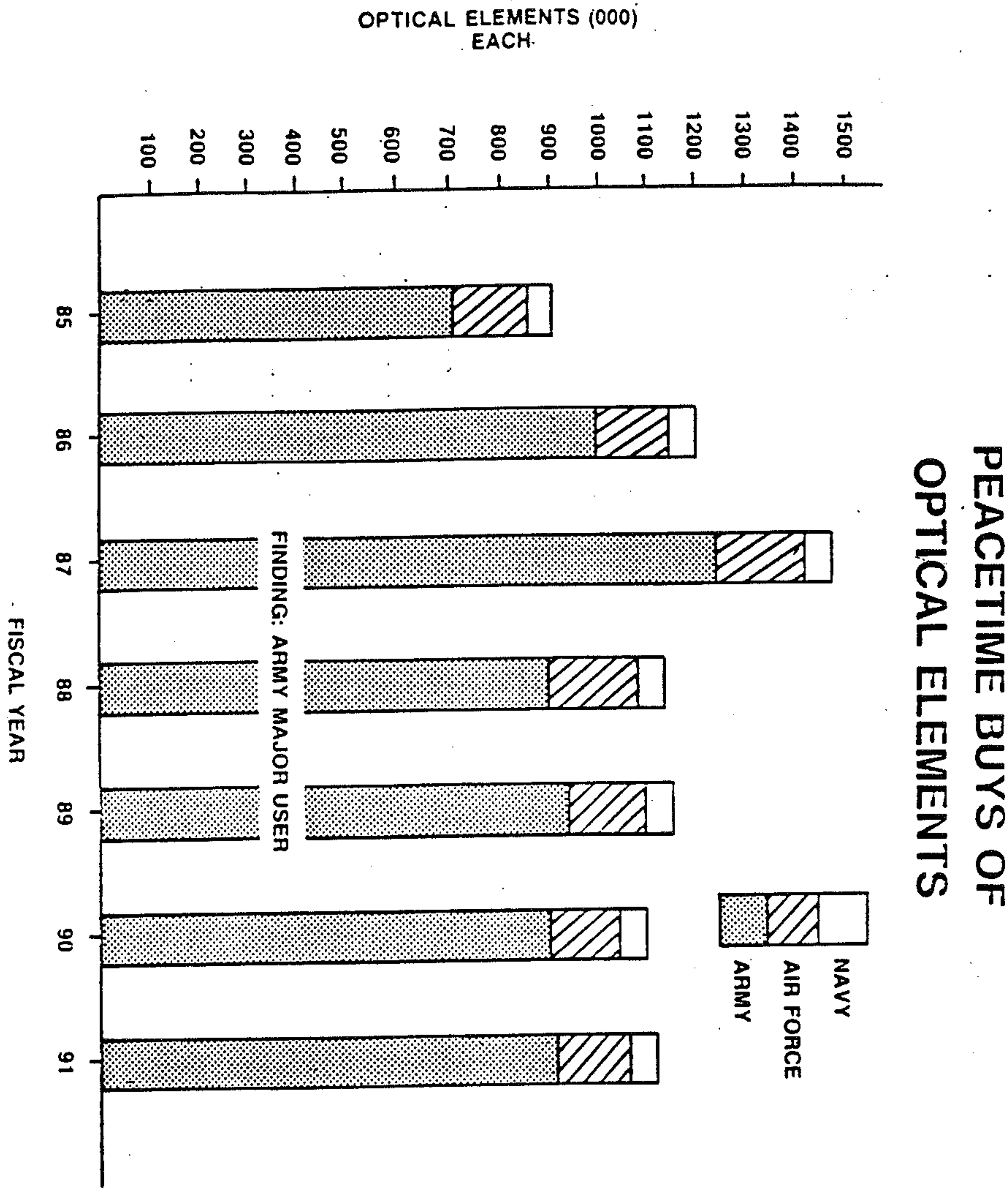
2.4.1 DOD Requirements

2.4.1.1 Peacetime Requirements

Peacetime requirements for precision optics, as shown in figure 1, were derived from the FY87 President's Budget, Procurement Appropriations, Army, Feb 86, FY 84-91. The President's Budget lists weapon system buys projected to FY91. Those systems using precision optics were identified and the number of precision optical elements per system determined. (Not all CIL items are in the President's Budget and not all items procured during peacetime FY 84-91 are on the CIL.) Based on this information, peacetime requirements were estimated to average approximately 1.2 million per year or 100,000 per month.

By analyzing those systems being procured for the next five years, the study team could identify systems being procured offshore. (See figure 2.)

FIGURE 1


OPTICAL ELEMENTS (000)
EACH
PEACETIME BUYS OF
OPTICAL ELEMENTS
NAVY
AIR FORCE
ARMY
FINDING: ARMY MAJOR USER
100
200
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500
600
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85
86
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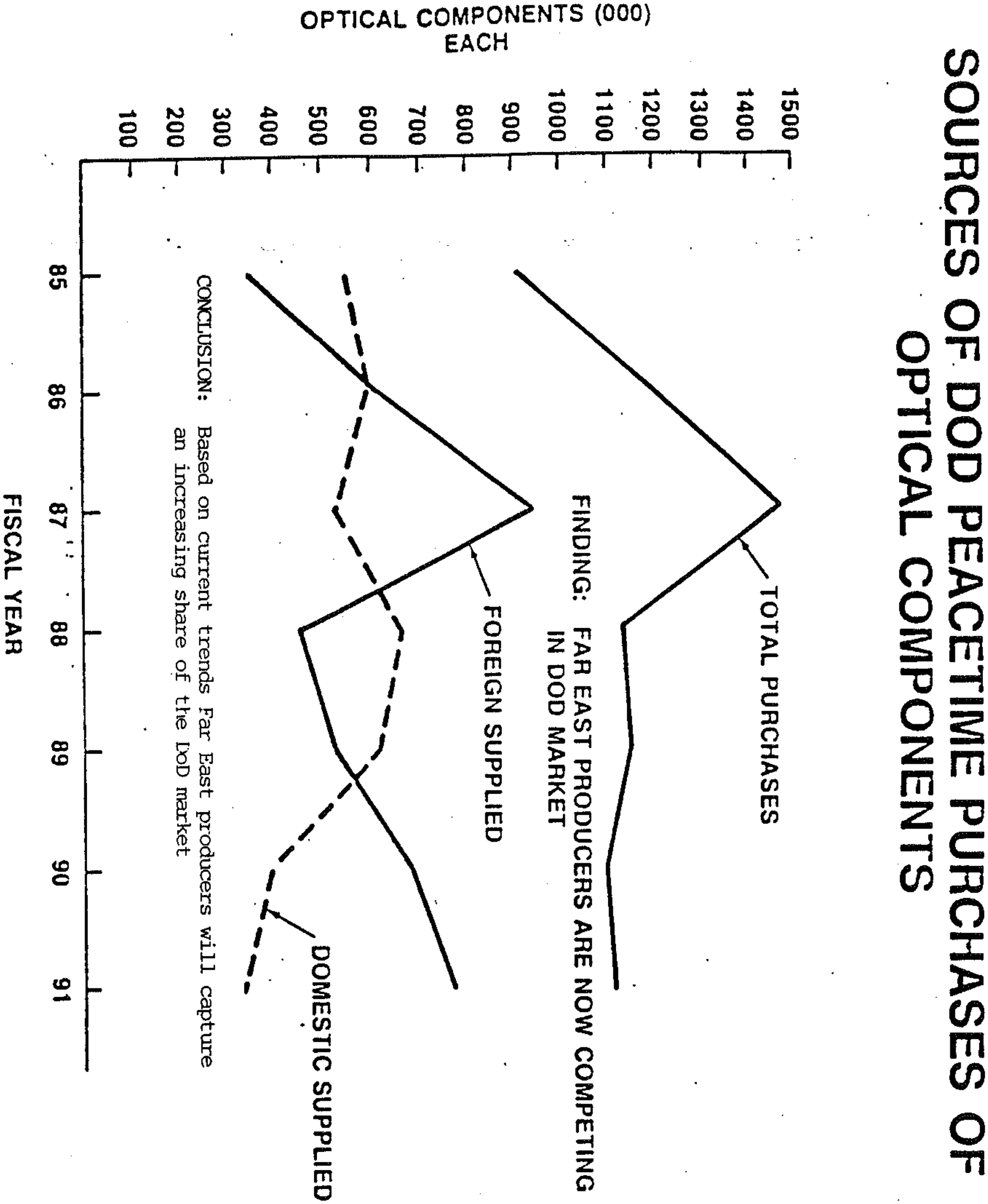
FISCAL YEAR

FIGURE 2


SOURCES OF DOD PEACETIME PURCHASES OF OPTICAL COMPONENTS
OPTICAL COMPONENTS (000) EACH
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
85
86
87
88
89
90
91
FISCAL YEAR
TOTAL PURCHASES
FOREIGN SUPPLIED
DOMESTIC SUPPLIED
FINDING: FAR EAST PRODUCERS ARE NOW COMPETING IN DOD MARKET
CONCLUSION: Based on current trends Far East producers will capture an increasing share of the DoD market

2.4.1.2 Mobilization Requirements

Army mobilization requirements for precision optics were taken directly from the AMC FAR Assessment Study. Air Force and Navy requirements were determined through data requests to procurement elements within each Service and analysis of the available critical item list (CIL) information.

2.5 INDUSTRY CAPABILITIES

2.5.1 Peacetime Production Capability

2.5.1.1 Practical Capacity

Nine firms responding to the Department of Commerce industry survey reported a combined practical capacity to grind and polish 3,795,014 optical elements in 1985. Practical capacity, sometimes referred to as engineering or design capacity, is the greatest level of output a plant can achieve within the framework of a realistic work pattern. These firms are estimated to represent about 85 percent of total U.S. precision optics production capacity. Almost 28 percent of this total was allocated for defense related production. About 97 percent of capacity is used to produce optical elements in the visible range (lenses, prisms, mirrors, other flats). The remaining three percent of capacity includes infrared and ultraviolet optical

1985 U.S. Optical Element Production Capacity

Category	Capacity (units)	Capacity Utilization	Defense Capacity (units)	Percent Defense
Visible Optics				
Lenses	2,017,916	64.3%	704,253	35.0%
Prisms	57,998	69.6	35,727	61.7
Mirrors	1,026,282	60.0	97,497	9.6
Other Flats	564,457	46.0	110,634	19.7
Other Optics				
Infrared	98,694	57.5	91,588	92.8
Ultraviolet	29,667	58.4	4,658	15.8
Total	3,795,014	60.4%	1,044,357	27.6%

categories. The military accounted for the largest shares of capacity for visible prisms (61.7 percent) and infrared optics (92.8 percent). In 1985, capacity utilization for the nine firms averaged only 60.4 percent, ranging from a low of 40 percent to a high of 100 percent for individual plants.

2.5.1.2 Interpreting Capacity Estimates

The surveyed firms were asked to comment on various factors that could change their capacity estimates. Capacity estimates were based on individual producers' 1985 product mix. Conditions that would lower estimated capacity include: tighter tolerances and specifications; the use of harder, more difficult to work materials; material availability; and increases in optical element varieties which would put additional demands on tooling and fixture capabilities. Conditions that would increase estimated capacity include: longer production runs; more skilled opticians; additional trained supervisors for second and third shifts; and more efficient production scheduling.

2.5.1.3 Ramp-Up Time

The precision optics industry reported it would take an average of 43 weeks to reach practical capacity from the average 60 percent capacity utilization rate it cited in 1985. The removal of one larger firm from this average would reduce the average "ramp-up" time to 25 weeks. Individual plants estimated this time from a low of only four weeks to a high of 78 weeks. The long time period needed to reach practical capacity is caused primarily by shortages of skilled opticians and long lead times for raw materials such as optical glass, grinding and polishing compounds, and coating materials.

2.5.1.4 Lead Times

Lead time information was collected separately for defense and non-defense orders. Lead time averages were reported by each surveyed firm as representative of the time between receipt of orders and delivery of finished optical components to the customer. The time customers spend in preparing orders and the time they take after accepting delivery to test, inventory, and catalog the components were not evaluated. However, customer processing and handling could add an additional 30 to 50 percent to overall lead times.

Average defense lead times were reported at 20 weeks in 1985. Individual plant defense lead times ranged from a low of only six weeks to a high of 26 weeks. Five plants, accounting for over 80 percent of defense production, reported lead times of 20 weeks or more. Three firms reported they were experiencing increases in their defense lead times. Reasons given included increasingly complex specifications and testing procedures, insufficient labor skill levels, inadequate equipment, and high volumes of government mandated paper work which delay the release of orders.

Average non-defense lead times were reported at 13 weeks, 35 percent less time than defense orders. Individual plants ranged from a low of only two weeks to a high of 26 weeks. Commercial orders have shorter lead times because they involve less paper work, less testing, often less product complexity, and they tend to use more standardized, less exotic raw materials in production.

The cause of long lead times includes raw material availability (mentioned by six firms) and tooling (mentioned by four firms). Shortages of opticians were mentioned by one firm, but opticians are not seen as a problem under current utilization rates. However, were orders to increase significantly, shortages of opticians would be a major cause of longer lead times. To shorten lead times firms recommended the stockpiling of raw materials, adding toolmakers, purchasing new equipment, better communications between customers and suppliers, and the issuance of higher volume orders.

2.5.1.5 Capacity Conversion from Commercial to Defense Production

A healthy precision optic commercial base that can be redirected or converted to supply expanded military needs in a surge or mobilization emergency is an important strategic asset that can significantly enhance national security. Historically, a large domestically based commercial optical element sector provided the skilled opticians, investment, research and development, managerial skills and overhead that largely underwrote defense purchases. However, the commercial optical element base has eroded in the face of rapidly rising element imports and the loss of the optical end market to overseas suppliers. Consequently, the Department of Defense has risen from a relatively minor purchaser to the U.S. optical component industry's largest single customer, currently acquiring about 42 percent of the value of U.S. component production.

The conversion potential of commercial production capacity to military production has diminished with declines in the commercial base. Most firms cited shortages of skilled opticians and limited testing, inspection, and coating equipment as constraining their capability to switch from commercial to defense production. This concern is complicated by a growing reliance on imported machinery and equipment and related spare parts/services. One larger firm estimated a conversion to military production, assuming availability of all necessary inputs, would take a year or more to accomplish.

Defense production generally requires tighter tolerances and specifications than commercial production. The raw glass is frequently ordered in smaller volumes and often made of special blends which creates scheduling problems and increases lead times for the glass producer. Additionally, the skill level of many opticians, while adequate for most commercial work, may be inadequate to maintain low enough defect levels to keep costs and lead times under control and still meet defense requirements. Defense production also requires more metrology equipment such as auto collimators and interferometers, testing equipment to measure salt and humidity resistance, and equipment to test for vibration integrity. Further, expensive vacuum coating equipment would be needed. Availability of this needed equipment in an emergency will add to the already long lead times necessary for conversion.

The conversion potential of the domestic optical element sector to military production appears inadequate to support a rapid increase in defense requirements. The situation may deteriorate further in the future as foreign incursions into commercial end markets continue to undermine the U.S. commercial production base. The growing dependence of U.S. firms on the volatile and unpredictable military market could make investment in modern equipment less attractive and more difficult to justify. Moreover, the already diminished pool of highly skilled opticians will be difficult to maintain in the more volatile military market. In addition, essential civilian requirements (e.g., microscopes and lasers for medical use, or sophisticated optical testing and inspection equipment needed in a number of defense related manufacturing industries) will make claims on optical component capacity during an emergency and could be an additional limit to conversion.

2.5.2 Surge and Mobilization Capabilities

Surge and mobilization production capabilities for precision optics were reported by the nine firms in their survey responses. Surge, for this study, is defined as the maximum sustainable level of defense production within an existing establishment by the end of six months. During a surge, commercial deliveries are to be maintained as well. Idle capacity and additional labor can be employed. Under a mobilization scenario, defense production is to be increased to the maximum sustainable level after 12 months. Commercial production is restricted to 25 percent of base year (1985) levels, and government financial and other assistance is available. In a mobilization, existing plant facilities can be expanded over the period.

In the analysis of the firms' surge and mobilization capabilities, average 1985 monthly defense production was used as a proxy for peacetime defense requirements. Firms were asked to report their monthly defense production capability after three months and six months for a surge, and to target a doubling of production by the end of the six months. For mobilization, monthly production capability was reported after six and twelve months, with a target of quadrupling production after one year.

2.5.2.1 Surge Capabilities

For a surge, the following table shows that the firms cannot increase production enough to meet the targeted twofold increase, with only a 46.7 percent increase in production levels after six months. In individual product categories, all visible optics failed to meet production targets, while the more specialized infrared and ultraviolet optics were more successful. Visible optics, however, account for the bulk of peacetime defense needs; 91.4 percent on a unit basis, and 43.7 percent on a value basis. Infrared optics, although a small volume item, are much more significant to national defense in terms of value, accounting for over one half of total dollar defense shipments. Moreover, almost 93 percent of infrared production is utilized for defense purposes.

Surge Production Capabilities
(in average monthly units)

Category	1985 Defense Production	3 Month Production Rate % Gain	3 Month Production Rate Quantity	6 Month Production Rate % Gain	6 Month Production Rate Quantity
Visible Optics					
Lenses	37,716	14.3%	43,109	37.5%	51,860
Prisms	2,070	20.3	2,490	39.1	2,879
Mirrors	4,886	16.5	5,692	39.6	6,821
Other Flats	4,248	18.8	5,047	44.9	6,155
Other Optics					
Infrared	4,383	54.1	6,754	115.5	9,445
Ultraviolet	227	133.0	529	506.2	1,376
Total:	53,530	18.9%	63,622	46.7%	78,537

2.5.2.2 Mobilization Capabilities

Under a mobilization scenario, the same conclusion is drawn: visible optics categories cannot be produced in sufficient quantities to satisfy the targeted quadrupling (300 percent increase) of production within the one year period. Weaknesses are particularly evident in the mirror and other flats categories, with increases of only 77.4 percent and 88.4 percent, respectively, after 12 months. On the other hand, the infrared and ultraviolet optics are able to meet the objective, with the ultraviolet showing the strongest potential for increased production.

Mobilization Production Capabilities
(in average monthly units)

Category	1985 Defense Production	6 Month Production Rate % Gain	6 Month Production Rate Quantity	12 Month Production Rate % Gain	12 Month Production Rate Quantity
Visible Optics					
Lenses	37,716	105.7%	77,582	273.2%	140,756
Prisms	2,070	138.4	4,935	227.3	6,775
Mirrors	4,886	39.6	6,821	77.4	8,668
Other Flats	4,248	44.9	6,155	88.4	8,003
Other Optics					
Infrared	4,383	149.3	10,927	315.7	18,220
Ultraviolet	227	1060.8	2,635	1060.8	2,635
Total:	53,530	103.7%	109,055	245.8%	185,057

2.5.2.3 Bottlenecks to a Surge/Mobilization

The firms were also requested to provide details on specific bottlenecks they foresaw in attempting to increase production for a surge or mobilization. Among the problems that would be encountered is the limited availability of supplies and raw materials due to the inadequacy of domestic sources and reliance on foreign suppliers. In an emergency situation, the continued availability or deliverability of these items may be in question.

Another major area of concern is the supply of equipment and machinery related to spare parts for the grinding, polishing, coating and testing processes. As with raw materials, much of this equipment originates abroad, domestic production capacity is limited, and long lead times are common. Under surge or mobilization conditions, pressures on the optical equipment and machine tool industries would be great, leaving doubt as to the availability of vital equipment.

The most often mentioned bottleneck to increased production relates to the supply of skilled labor. This problem was named by every firm and across almost every optics-producing operation and process - coating, grinding, polishing, testing, hand correction and assembly. As discussed in detail in the section on Work Force, an extended period is required to train opticians and other vital optical personnel.

2.5.2.4 Critical Work Force Requirements in a Surge/Mobilization

In the survey, optics producers were asked to identify critical occupations and the number of workers in each occupation they would need to meet surge and mobilization targets. Critical occupations are defined as those for which an anticipated or potential shortage of qualified personnel would occur during a surge or mobilization. In general, critical occupations would include skilled occupations that require an extended training period. The table below presents the aggregated predictions for needed employment of critical occupations during a surge or mobilization. Also shown is the range given of the training period for these positions.

Number of Critical Workers Needed in a Surge and Mobilization

Critical Occupation	Current Employment	Number Needed to Surge	Number Needed to Mob	Training Period (Months)
Opticians	216	313	470	2-36
Engineers	67	101	167	2-48
Testing & Quality Control	34	50	90	6-24
Other Production Workers	209	296	488	4-48
Coating Opticians	105	139	205	4-18
Total	631	899	1,420	

2.5.3 Work Force

2.5.3.1 Trends

Since 1981, the optics industry has experienced an almost 50 percent decline in its work force. Closer examination of this industry revealed substantial work force reductions across the board in precision optic occupations. Producers reported a total of 1,655 employees in 1986, down from 3,096 in 1981. This overall employment decline has dramatically affected this industry's production capability, particularly under surge and mobilization conditions.

Precision Optics - Work Force

	1981	1982	1983	1984	1985	1986
Scientists and Engineers	253	251	243	243	369	198
Production Workers	2,457	2,265	1,232	1,252	1,353	1,108
Administration & Other	386	412	324	328	358	349
Totals	3,096	2,928	1,799	1,823	2,080	1,655
Opticians (also included in above numbers)	1,015	938	727	723	741	602
Percent of Work Force	32.7%	32.0%	40.4%	39.6%	35.6%	36.3%

Optical Materials - Work Force

	1981	1982	1983	1984	1985
Scientists & Engineers	114	101	103	103	97
Production Workers	835	764	658	650	703
Administration & Other	245	221	223	230	246
Totals	1,194	1,086	984	983	1,046

2.5.3.2 Shortage of Skilled Opticians

Specialized and lengthy training is required by some of the work force. While unskilled labor is plentiful, the availability of journeymen and master opticians dropped from 1,015 in 1981 to only 602 in 1986, a 41 percent decline. One firm reported that 90 percent of its master opticians are approaching retirement age and no viable programs are in place to supply future needs.

The definition used in the industry survey to describe opticians was technicians who grind, polish, and test precision optical components (i.e., lenses, prisms, etc.) and assemble these components into optical systems. (Note: This definition of opticians does not include "dispensing opticians" who grind eyeglasses. Dispensing opticians are substantially different from precision optical opticians and can not be converted to precision optical production without extensive retraining.)

To become highly skilled, an optician requires two to three years of training and usually apprentices under a master optician. The skills of an optician are highly technical and most training is currently provided on the job. Skills and knowledge required include:

- Skills

  - equipment operation and maintenance
  - use of various grinding and polishing compounds, and
  - testing with a micrometer, spherometer, lens bench, auto collimator and interferometer

- Knowledge

  - fundamental theory of light
  - principles of refraction and diffraction
  - characteristics of glass and other refractive materials
  - processing procedures
  - elementary mathematics
  - blueprint reading, and
  - interpretation of specifications, tolerances and tests

Other critical occupations in short supply that could constrain a surge or mobilization are coating technicians, optical assemblers, quality controllers, grinders, and polishers.

2.5.3.3 Industry Sponsored Training Programs

The optical element producers have formed through the American Precision Optics Manufacturing Association (APOMA), a committee to institute a future training program. It will be an apprentice-type program with training conducted on the job. Two years of this training will be sponsored by APOMA. At the end of two years, the top 10 percent of those trained will be eligible to continue for another year of more intensive training to become supervisors and foremen. The others will go on to become opticians. By the end of 1987, APOMA expects to have the training program in full operation.

Back in 1980, a training program was developed by one company with a local community college. In this program a two year A.S. degree in precision optics was established. In addition to donating $100,000 worth of equipment, this company provided instructors and laboratory assistants. The company noted that college level training was necessary to acquire the needed specialized skills more rapidly than on the job training. It believes that two years of college training are equal to four years of training on the job. However, a downturn in the economy caused demands for skilled employees to lessen. The program, which received little support from the local community, was inactivated in 1984.

While this program is currently inactive, it could be reactivated within four to six months. Another company responding to the survey noted that increased business would be needed to offset the training costs of more opticians.

2.5.3.4 Shift Productivity

Producers noted that they could significantly increase production by operating multiple shifts. Using one shift as a starting point, producers estimated that production could be increased an average of 73 percent with the addition of a second shift and by 112 percent with the addition of both a second and third shift. However, the shortage of skilled employees would severely limit projected increases.

The precision optics producers also reported the number of production workers employed by shift and major production operation for 1985 and estimated what those numbers would be if they were operating at practical capacity. The total increase in production workers required to reach practical capacity was estimated at 82.2 percent or 1,113 workers. Since the industry was using 60.4 percent of its capacity in 1985, production at 100 percent of capacity would amount to a 65.6 percent production increase (i.e., (100-60.4)/60.4 = .656).

The smaller percent increase in production than in the work force translates into about a 20 percent decline for the additional workers in the productivity of labor. A productivity drop of this magnitude may not be acceptable during an extended surge or mobilization period with the expected shortage of opticians. To counteract such a drop, additional capital equipment would be needed to restore the capital/labor ratio closer to its optimal range.

Percentage increases in employment vary significantly by major production operation when expanding to practical capacity. The employment increase for the coating operation was the smallest at only 55.9 percent. All other operations show diminishing returns to scale or declines in labor productivity with incremental additions to the work force. Employment in the assembly operation showed the greatest increase at 119.9 percent with hand correction and rough grinding slightly less.

NUMBER OF PRODUCTION WORKERS PER SHIFT IN 1985 AND THE NUMBER REQUIRED IF OPERATING AT PRACTICAL CAPACITY

Operation	1985 Operations Shift 1st	2nd	3rd	Practical Capacity Shift 1st	2nd	3rd	Overall Percent Increase
	(60.4% utilization)			(100% utilization)			
Rough Grinding	68	28	7	104	67	48	112.7%
Fine Grinding	70	19	4	87	52	36	88.2%
Polishing	197	87	30	250	166	136	75.8%
Hand Correction	31	8	0	41	27	16	115.4%
Coating	113	68	23	141	111	66	55.9%
Assembly	86	20	0	115	78	40	119.9%
Testing	80	36	0	122	86	22	98.3%
Other	237	93	47	397	144	113	73.5%
Total	882	359	111	1,257	731	477	82.2%

2.6 Industry Performance

2.6.1 Shipments

Perhaps the most startling finding of this assessment is the small share of the U.S. market comprised of domestically produced precision optical elements. It is estimated that U.S. production in units accounts for less than two percent of total U.S. consumption. On a value basis, the U.S. share of shipments is higher because many U.S. firms continue to participate in highly specialized, low-volume optic markets. In these markets, a single element (such as for the space telescope or for the research being done by Lawrence Livermore Laboratories on laser fusion) may be several yards in diameter and cost several million dollars. This compares with an average import price of only three or four dollars. Total value shipment numbers are not available and it is with prudence that we estimate the U.S. producers' share at between 30 and 40 percent of the total U.S. market.

Unit shipments of precision optics by the nine surveyed firms varied over the 1981-1985 period. In 1981, 1.7 million units were shipped. This number rose to 2.1 million in 1982. Shipments declined to only 1.9 million or by 7.6 percent in 1983, but rose along with several major end markets including the military in 1984 to 2.5 million. 1985 brought a slump in shipments to 2.3 million although some individual firms showed improvement. A further overall decline is expected in 1986 due to continued pressures from foreign competitors and continued offshore migration of commercial end-markets.

Among individual optical component categories, the same general unit shipment trends prevail, except that shipments of visible mirrors showed expansion in 1985 over their 1984 levels. Ultraviolet optics have experienced continued growth over the entire five year period.

UNIT SHIPMENTS BY MAJOR COMPONENTS
1981-1985
(In Thousands)

VISIBLE OPTICS

LENSES	1981	1982	1983	1984	1985
Non-Defense	656.7	909.0	782.0	925.3	846.0
Defense	190.7	252.1	295.6	429.2	452.6
Total	847.4	1161.1	1077.6	1354.4	1298.6
Defense Share	22.5%	21.7%	27.4%	31.7%	34.9%

PRISMS	1981	1982	1983	1984	1985
Non-Defense	18.5	17.2	11.6	26.9	15.5
Defense	26.8	27.8	13.9	38.1	24.8
Total	45.3	45.1	25.5	65.0	40.3
Defense Share	59.2%	61.8%	54.4%	58.7%	61.6%

MIRRORS	1981	1982	1983	1984	1985
Non-Defense	349.3	450.7	429.2	514.2	557.5
Defense	20.2	24.1	32.2	50.2	58.6
Total	369.6	474.8	461.4	564.5	616.1
Defense Share	5.5%	5.1%	7.0%	8.9%	9.5%

OTHER FLATS	1981	1982	1983	1984	1985
Non-Defense	398.1	296.9	254.5	335.5	208.7
Defense	32.2	46.3	48.3	59.6	51.0
Total	430.3	343.2	302.8	395.1	259.7
Defense Share	7.5%	13.5%	16.0%	15.1%	19.6%

INFRARED OPTICS	1981	1982	1983	1984	1985
Non-Defense	5.9	5.1	3.9	5.4	4.1
Defense	42.3	41.9	39.8	52.5	52.6
Total	48.2	46.9	43.7	57.9	56.7
Defense Share	87.8%	89.2%	91.0%	90.7%	92.8%

ULTRAVIOLET OPTICS	1981	1982	1983	1984	1985
Non-Defense	5.3	5.5	6.4	12.4	14.6
Defense	2.7	2.7	4.3	4.3	2.7
Total	8.0	8.2	10.7	16.7	17.3
Defense Share	34.1%	33.2%	40.3%	25.8%	15.7%

TOTAL ALL OPTICS	1981	1982	1983	1984	1985
Non-Defense	1433.7	1684.4	1487.6	1819.7	1646.3
Defense	315.0	394.9	434.1	633.9	642.4
Total	1748.8	2079.3	1921.7	2453.6	2288.6
Defense Share	18.0%	19.0%	22.6%	25.8%	28.1%

Overall, just over 28 percent of unit optics shipments in 1985 for the nine firms went to defense purposes. This percentage has risen consistently over the period, demonstrating the firms' increasing reliance on military sales as the growth of commercial markets has been stifled by foreign competition. The percentage of optics used for defense purposes varies greatly from component to component, ranging from a low of 15.7 percent for ultraviolet types to a high of 92.8 percent for infrared types. Defense shipments, in contrast to commercial shipments, show consistent growth over the 1981-1985 period for most component categories and in the overall total.

Total value of shipments of precision optics follows the pattern of unit shipments closely, but price increases mask the decline in unit shipments in 1985.

DOLLAR SHIPMENTS BY MAJOR COMPONENTS
1981-1985
(In Thousands of Current Dollars)

VISIBLE OPTICS	1981	1982	1983	1984	1985
Non-Defense	$23,056	$26,110	$22,941	$28,772	$28,343
Defense	7,846	7,837	6,892	6,983	9,392
Total	30,902	33,947	29,833	35,755	37,735
Defense Share	25.4%	23.1%	23.1%	19.5%	24.9%

INFRARED OPTICS	1981	1982	1983	1984	1985
Non-Defense	$ 341	$ 312	$ 836	$ 1,011	$ 958
Defense	4,645	10,072	12,430	12,523	11,740
Total	4,986	10,384	13,266	13,534	12,698
Defense Share	93.2%	97.0%	93.7%	92.5%	92.5%

ULTRAVIOLET OPTICS	1981	1982	1983	1984	1985
Non-Defense	$ 210	$ 211	$ 239	$ 310	$ 348
Defense	362	362	442	443	365
Total	572	573	681	753	713
Defense Share	63.3%	63.2%	64.9%	58.8%	51.2%

TOTAL ALL OPTICS	1981	1982	1983	1984	1985
Non-Defense	$23,607	$26,633	$24,016	$30,093	$29,649
Defense	12,853	18,271	19,764	19,949	21,497
Total	36,460	44,904	43,780	50,042	51,146
Defense Share	35.3%	40.7%	45.1%	39.9%	42.0%

Defense shipments measured in value terms present a different picture. On a value basis, 42 percent of total shipments went to defense applications. Individual categories ranged from 25 percent to defense for visible optics to over 92 percent for infrared. The share of shipments in terms of value devoted to defense is much more volatile than the equivalent unit calculation, changing from year to year with no particular pattern apparent. This is because of the wide fluctuations in unit prices of optics reflecting the wide variability in their size, quality, and type.

2.6.2 Prices

Average prices (dollars per unit) were calculated for the major categories of optics and are presented below. Again care must be taken in interpreting these figures because of the wide variation in price for different optics, even within the same general category. On the whole, defense optics are more expensive than their non-defense counterparts, averaging $33 per item versus $18 for commercial optics in 1985. In the visible and infrared optics categories, however, the commercial price has edged slightly higher than the defense price in recent years. This reflects the fact that, among the nine surveyed firms, many pursued the more specialized, higher-valued commercial markets as foreign producers became dominant in the low end of the market. Furthermore, increased competition among domestic producers for defense business has brought defense prices down relative to commercial prices. To a great extent, high end commercial and defense applications have become the only markets that remain for domestic producers as traditional markets, such as lenses for cameras, binoculars and telescopes are almost completely offshore today. In the future, defense tolerances and specifications are expected to become tighter and more sophisticated. This could drive defense costs and prices higher in years to come.

AVERAGE PRICE OF MAJOR COMPONENTS
1981-1985

VISIBLE OPTICS	1981	1982	1983	1984	1985
Non-Defense	$16.21	$15.60	$15.53	$15.97	$17.41
Defense	29.06	22.37	17.67	12.10	16.00
Total	18.26	16.77	15.98	15.03	17.04

INFRARED OPTICS	1981	1982	1983	1984	1985
Non-Defense	$57.96	$61.36	$212.45	$187.40	$235.90
Defense	109.77	240.61	312.43	238.59	223.19
Total	103.45	221.19	303.43	233.82	224.10

ULTRAVIOLET OPTICS	1981	1982	1983	1984	1985
Non-Defense	$39.87	$38.52	$ 37.40	$ 24.95	$ 23.87
Defense	133.09	133.09	102.31	102.55	134.19
Total	72.62	69.90	63.59	44.97	41.21

TOTAL ALL OPTICS	1981	1982	1983	1984	1985
Non-Defense	$16.47	$15.81	$ 16.14	$ 16.54	$ 18.01
Defense	40.80	46.26	45.52	31.47	33.47
Total	20.85	21.60	22.78	20.40	22.35

2.6.3 Imports and Exports

We estimate that the United States imported a staggering 279.2 million optical elements in 1986. This import total was more than one hundred times as many optical elements as the surveyed firms produced domestically (i.e., elements that were ground and polished). In terms of value, imported elements were estimated to equal about a billion dollars in 1986.

Over 80 percent of these imports originated in the Far East, primarily Japan, Taiwan and South Korea. Over 95 percent of the imports entered the United States as "contained elements" in end-products such as cameras, telescopes, photographic lenses and binoculars. Only 4.7 percent of the imported elements entered as "unmounted" optical elements. In absolute terms, element imports have increased by over 140 percent since 1978.

Exports of optical elements, on the other hand, ranged between 27.1 and 48 million units during the 1978 to 1986 period. Most exports, however, are actually re-exports of either mounted or unmounted imported elements assembled in the United States into end-products for export. The U.S. has maintained a small trade surplus with the European Community. A huge trade deficit exists with the Far East. (See Appendix E for a detailed accounting of imports and exports.)

TOTAL U.S. IMPORTS AND EXPORTS OF OPTICAL ELEMENTS, 1978-1986

(in millions of optical elements)

Year	Imports	Exports
1978	116.3	31.8
1979	124.3	41.5
1980	128.6	36.6
1981	144.8	34.8
1982	148.2	48.0
1983	156.4	31.6
1984	223.2	27.1
1985	280.8	36.6
1986	279.2	35.6

Source: Department of Commerce

Import statistics were collected for 11 major end-products (cameras, binoculars, microscopes, etc.) containing optical elements. Imported optical elements "contained" in these end-products were then estimated. Of the end-products, still cameras contained almost 44 percent of the total imported elements in 1986, which was by far the largest single end-product share. Other major end-products with significant shares included telescopes (15.4 percent), mounted photographic lenses (13.8 percent), and binoculars (12.2 percent).

Camera imports rose dramatically since 1983 from only 30.1 million (contained elements) to 122.3 million elements in 1986, more than a 300 percent increase. Imports of contained camera elements from Taiwan grew from under 5 million to over 50 million in this short period as both American and Japanese multinationals opened export facilities there. Taiwan emerged with the largest share of camera exports to the U.S. (41.4 percent), surpassing Japan (34.6 percent) in 1985. Taiwan also became the major supplier of motion camera elements (66.1 percent), edging past Japan (23.4 percent) in 1984. Motion cameras, however, are the smallest of the 11 end-product markets, and in fact have declined in overall number

1986 U.S. IMPORTS OF CONTAINED OPTICAL ELEMENTS
BY END PRODUCT AND BY MAJOR COUNTRY OF ORIGIN

End Product	Imported elements (millions)	percent of total	Major Source	percent of total
Still Cameras	122.3	43.8%	Taiwan	41.4%
Telescopes	42.9	15.4	Japan	40.7
Photographic Lenses, Mounted	38.5	13.8	Japan	78.2
Binoculars	34.0	12.2	Japan	54.9
Optical Elements, Unmounted	13.2	4.7	Japan	65.7
Optical Elements, Mounted	10.8	3.9	Japan	85.1
Photocopiers	8.6	3.1	Japan	94.4
Projection Lenses, Mounted	4.7	1.7	Japan	85.6
Microscopes	2.0	.7	Japan	79.3
Projectors	1.6	.6	Japan	21.6
Motion Cameras	.5	.2	Taiwan	66.1
Total	279.2	100.0%	Japan	50.4%

Source: Department of Commerce

since 1978. Japan has the largest share of the import market for each of the other nine end-product categories.

Further analysis of this information showed that not only have domestic producers lost ground to imports, but that large cross sections of element "end-markets" have moved offshore. This occurred despite rapid growth in many optics end markets in the U.S., in which U.S. firms failed to participate. The large scale displacement of end markets has substantially reduced the overall size of the element market available to domestic producers and could jeopardize their long term viability.

SHIFTS IN U.S. IMPORT TRADE WITH JAPAN, TAIWAN AND SOUTH KOREA

(in millions of optical elements)

Year	Total Imports	Imports and Percent of Total from Japan		Taiwan		S. Korea		Three Country Import Total	
	units	units	%	units	%	units	%	units	%
1978	116	86	70.3%	7	5.7%	6	5.0	98	84.5%
1979	124	94	75.8	7	5.3	5	4.2	106	85.3
1980	129	101	78.5	5	3.8	5	3.9	111	86.2
1981	145	109	74.9	5	3.5	7	4.9	121	83.3
1982	148	112	75.4	7	4.7	8	5.7	127	85.8
1983	156	117	74.5	9	5.7	9	6.0	135	86.3
1984	223	155	69.6	23	10.1	16	7.3	194	87.1
1985	281	155	55.1	46	16.4	23	8.0	223	79.5
1986	279	141	50.4	63	22.4	23	8.2	226	81.0

Growth Rates by Country, 1978-1986

World	Japan	Taiwan	S. Korea	Three Countries
140%	64%	843%	295%	130%

Source: Department of Commerce

A major shift in U.S. import patterns has occurred in recent years with Japan losing large portions of its share of the U.S. import market to Taiwan and South Korea. Japan's share of total imported optical components peaked at 78.5 percent in 1980 and remained near or above 70 percent through 1984. However, since 1984 Japan's share of the U.S. import market has fallen to 50.4 percent in a trend that is expected to continue.

Most of Japan's lost share was captured by Taiwan and South Korea, which expanded their share of the U.S. import market from 17.4 percent in 1984 to 30.6 percent in 1986. Imports from Japan also declined in absolute terms after peaking in 1984 at 155.4 million elements. By 1986, imports from Japan had fallen to 140.6 million elements or a decline of 9.5 percent. This occurred while total U.S. imports expanded by over 25 percent from 223 to over 279 million imported elements.

Several important circumstances underlie this shift. Perhaps paramount among these is the competitive struggle between large end user firms such as Fuji~~tsu~~san and Kodak. In efforts to reclaim, maintain or expand market shares these end users must seek out least cost supply alternatives which are clearly, in the case of optics, located in the developing economies of the Far East. In addition, newly industrializing countries such as Taiwan and Singapore encourage companies to locate in their countries, offering tax holidays (up to ten years in the case of Singapore) and other incentives to attract them. Moreover, Japan's wage scale has increased to near parity with the United States making Japan much less attractive from a cost standpoint for the production of standard type optical elements.

Associated with these conditions, it also appears the U.S. market is saturated. As evidence of this, optical element imports peaked at 280.8 million units in 1985 after years of solid growth. This could further motivate foreign (and domestic) producers to find lower cost production alternatives needed to either maintain or expand their market shares. Thus the on-going exodus of optics production capacity from high cost industrialized countries (especially from Japan) to low cost countries in the Far East should continue. Not surprisingly, many recently constructed Far East manufacturing facilities are owned by Japanese, European and American firms.

In this rapidly changing environment, Japanese firms are rethinking their long term optics strategy. We expect some Japanese firms to increase the sophistication of their domestic production capabilities and challenge American firms in the high value end of the market in the near future. This strategy may include opening or purchasing some plants in the United States. Recently a Japanese concern purchased Pyramid Optical Company, perhaps motivated by the opportunity to acquire technology. Pyramid had developed a unique processing capability to produce high precision retro-reflectors (pyramid shaped optics used in communication satellites to return light signals to precise locations) at low cost. Furthermore, continued investment in lower cost production facilities in less developed countries could help Japanese firms maintain a presence in lower valued standard optical markets.

2.6.4 Investment

Investment in new plant and equipment by the nine precision optics firms varied over the 1981-1985 period, as shown in the table below. Total aggregated investment spending was at its highest in 1981, at over $13.2 million. This total dropped slightly in 1982 to $11.8 million, and then fell dramatically by 52 percent in 1983 due to poor industry performance that year. Investments improved somewhat from this depressed level in 1984, reaching $7.8 million. The upward trend continued in 1985, with investment at $9 million. Indications from the firms are that current levels of investment will be maintained over the next two to three years.

INVESTMENT SPENDING

(In Thousands of Dollars)

Investment	1981	1982	1983	1984	1985
In Plant	$4,644	$4,597	$ 883	$ 850	$2,146
In Machinery/Equipment	8,589	7,219	4,783	6,923	$6,855
Total	$13,233	$11,816	$5,666	$7,773	$9,001

Investment in machinery and equipment accounts for the bulk of total investment, running at about 75 percent in 1985. The two broad categories of investment (in plant and in machinery/equipment) followed the same pattern over the period. Plant investment, however, is much less consistent than investment in machinery, as it tends to occur in large, intermittent blocks rather than evenly distributed over time. Both investment categories attained their highest level in 1981 before a sharp drop, followed by a partial recovery in the last two years. This recent increase, however, did not bring investment back to the high levels of the early 1980's.

Firms have invested heavily in recent years in an attempt to reduce high costs and survive in the face of stiff foreign competition. For example, most firms are investing in new, sophisticated machinery (such as diamond point turning machines, and high-speed polishers and coaters) that reduce labor needs, shorten equipment set-up times and lower scrap rates, thereby increasing overall productivity. Semi-automatic manufacturing processes, statistical process controls, and cost accounting systems are also being installed. Some firms are attempting to reduce unit overhead and general accounting costs by expanding operations that spread fixed costs over greater production. These actions involve investment in both new plant and equipment. Others are diversifying their product mixes, and at least two firms are planning additional investment in their own Far East operations to capitalize on low production costs there.

2.6.5 Inventories

Inventory policy is highly variable from firm to firm. Several firms maintain little inventory of supplies and materials used to manufacture optics. These firms operate on a job by job basis, ordering necessary materials only after receipt of a customer's order. Other firms maintain larger inventories. The weighted average of inventory size (in days supply) across all firms (including those who said they had none) was 119 days for optical glass, 88 for filter glass, and 40 days for infrared materials. The lengthy on-hand supply of optical glass is partly a safety measure because there is only one remaining domestic source of supply, which raises concerns about the material's availability. However, minimum purchase quantities and associated price discounts are also important influences in maintaining inventory levels.

Among the optical materials firms, most held no inventory at all for the selected materials listed in the Department of Commerce survey. Of those that did, a one to three month supply of materials (e.g., hydrogen sulfide, zinc, hydrogen selenide) was average. Factors which influenced inventory policy included limited availability of some materials (inventory needed to compensate for long lead times), minimum purchase quantities, and price breaks for larger purchases. In the future, inventory levels may increase because of the deteriorating availability and expanding lead times for raw materials.

2.6.6 Research & Development

A related and perhaps more important area of spending than direct investment is research and development (R&D). All but two smaller firms reported the expenditure of at least some money trying to develop new materials, processes or products related to precision optics manufacture. The amount spent on R&D over the past five years is as follows.

R & D Expenditures

(in thousands of dollars)

1981	$3,663
1982	3,564
1983	3,676
1984	3,612
1985	3,829

The aggregate R&D amount is remarkably consistent from year to year, at around $3.6 million. (These amounts should be viewed with caution as they are based on a small sample. Moreover, one large firm accounts for most of the R&D expenditures.) Most of the expenditures are devoted to process and equipment development, with a smaller portion allocated to product development and materials research.

Several firms mentioned finished lens molding techniques as desirable to acquire. Also mentioned by the firms were development of machines and equipment to increase manufacturing productivity, development of more sophisticated coating technologies, and research in aspheric lens production. Several firms also use R&D expenditures to develop prototypes for customers. In many cases, the optical firm that develops the prototype may also be contracted to produce the element. However, if production volumes are large, the end user may designate a foreign concern to mass produce the components to save costs.

In a broader context, the United States may be gradually falling behind in optical research and technology development and losing the initiative to the Japanese. The U.S. has led the world in creating optics technology and establishing optical production capabilities since seizing the initiative from the Germans in the aftermath of World War II. When lasers began entering the market place in large numbers about 1970, R&D efforts by U.S. industry were given new life. However, this upsurge was temporary. U.S. R&D spending has suffered greatly in the last decade because of massive foreign encroachment into the U.S. market and a decline in U.S. Government involvement. Japanese firms are currently funding more optics research in American universities than is U.S. industry. The technologies developed through these programs will most likely be transferred offshore and eventually be translated into competitive advantages for the Japanese.

2.6.7 Profitability

The table below presents profitability information for the nine precision optics participants in the Commerce Department survey. It should be kept in mind that these figures are estimates. Several surveyed plants produce optics solely for internal consumption by other divisions of the same firm. These firms operate as "cost centers" and thus have no profitability data available. We estimated the overall industry profitability based on five valid survey responses.

PROFITABILITY

(In Thousands of Dollars)

	1981	1982	1983	1984	1985
Net Sales	$36,460	$44,904	$43,780	$50,042	$51,146
Cost of Goods Sold	29,350	36,058	33,360	37,782	37,848
Gross Profit	7,146	8,801	10,463	12,310	13,349
Net Income	984	539	2,145	3,503	4,347
Net Income/Sales	2.7%	1.2%	4.9%	7.0%	8.5%

As can be seen from the table, both gross profits and net income have increased over the period, except for a dip in net income in 1982. Profits have increased consistently despite fluctuations in shipment levels and in the face of foreign competition. This has been possible because of efforts by the firms to specialize in higher priced goods which elevate dollar sales. Furthermore, firms have been able to maintain increasing profit levels because of numerous actions they have taken to reduce overhead and production costs such as investing in more productive equipment, importing supplies and finished goods from overseas, and instituting productivity enhancing manufacturing techniques.

2.6.8 Plant Closings

Because of foreign competitive pressures many precision optics manufacturing plants have closed, reduced optical operations or switched production to more profitable products during the last decade. The result has been a major reduction in the size of the industry and its almost complete displacement from the larger volume optical production categories by foreign competitors.

Rochester, New York, the long time center of the optics industry, saw the closing of several plants including Ilex (visible and near infrared elements), Wallensach (lenses), and Bausch and Lomb (optical glass melting). Also, Eastman Kodak, a major element producer in Rochester, has dramatically reduced operations in recent years.

Reichert-Jung (formerly American Optical), the last full line scientific instrument producer remaining in the United States, shut down its Keene, New Hampshire facility in a consolidation move to improve production efficiency. Weaver, a Texas firm that produced elements for rifle scopes, went out of business several years ago. And most recently (in early 1987) J. L. Long of California (night vision optics) closed its doors because of insufficient business with few prospects for improvement.

Additional information on plant closings was obtained from respondents to the Department of Commerce industry survey. Because of unprofitable operations, Herron Optical Company, in Long Beach, California was sold by one of the surveyed firms after more than 20 years of successful operation. The new owner has since shut the facility down. A plant in Durango, Colorado that supplied elements for rifle scopes was closed in 1982 because the end-user placed 95 percent of its optics orders in foreign countries. Another firm consolidated its operations in 1983 by closing a facility in Dallas, Texas.

The Federal Government was also involved in a plant closing. In 1977, the Department of Defense closed down the Frankford Arsenal in Philadelphia for budgetary reasons. The Frankford Arsenal played a leading role in supplying optics to the military during World War II, when its work force swelled to about 19,000. In the 30 years following the War, the Arsenal was central to advances in all aspects of optical research including optical manufacturing technology, materials research and product development. Frankford made prototypes that were later contracted commercially for production, establishing new capabilities within private firms. The facility also manufactured low volume optics that private concerns were not interested in or could not produce profitably. Moreover, the Arsenal was a training ground for opticians, affording them hands-on experience which was transferable to industry.

2.7 SOURCES OF SUPPLY

The optics industry is becoming less integrated at the plant level as foreign competitive pressures have led many firms to subcontract out certain costly operations which can no longer be justified in-house or can be done more cheaply by either foreign or more specialized domestic firms. These same pressures have greatly expanded foreign sourcing and have increased foreign dependencies in recent years at all levels of optics production.

2.7.1 Subcontracting

All but one of the ten plants surveyed utilized at least one subcontractor, domestic or foreign, in some aspect of their operations. All types of optical element products (lenses, flats, reticles, aspherics, prisms) as well as the process of coating were subcontracted out. The most frequently subcontracted operation was coating, which five out of the ten surveyed plants used for at least part of their coating needs. The range of subcontractor use for coating was 5 percent to 100 percent. The main reason for using subcontractors for this specialized process was because the equipment is very expensive, making an in-house capability in low volume shops difficult to justify. Other frequently subcontracted items were reticles (4 out of 10 firms), flats (4 out of 10), lenses (4 out of 10), and aspherics (2 out of 10). The main reasons given for subcontracting these items were: (1) volume too small to be cost effective, (2) to take advantage of lower cost producers offshore, and (3) lack of in-house design and/or equipment capability.

Overall, the trend toward subcontracting has increased over the industry survey period (1981-85), and the firms expect this trend to continue in the future. Especially important will be the trend in shifting of domestic production of commercial quality optics to lower cost foreign producers, such as those in the Far East.

2.7.2 Supply Disruptions

Most plants (8 out of 10) reported that they had experienced shortages and/or long lead times in obtaining necessary materials and equipment that disrupted their operations. Of particular concern is the availability of optical glass, which is currently limited to one domestic producer. Infrared materials, although produced by several sources, is a long lead time item, as are various imported machines and equipment used in the optic-making process (including coating equipment, polishing machinery, and micro-optics production equipment). These availability problems are expected to continue in the future. Also in the future, at least one respondent foresaw a problem in the availability of skilled labor.

Among optical materials manufacturers, long lead time items included Germanium metal (12 to 18 months) and crystal growers for producing special optical materials. Moreover, several firms mentioned that there is only one source for hydrogen sulfide and hydrogen selenide gases used in the glass making process. A growing concern, especially in the event of a national emergency, is the availability of a whole range of imported raw materials used as blending agents in a wide variety of glasses. Schott Glass Technologies maintains the critical capability to formulate substitute glasses using available blending materials should imported materials be cut off. However, this highly specialized capability is at risk in the current environment. Should Schott shut down, domestic defense optical production capabilities would be substantially reduced.

2.7.3 Foreign Dependency

Most optical and optical material companies are reliant on imports to some degree. Overall, firms used an average of 32 percent imported optical and filter glass in their production, while 41 percent of infrared material was imported. If materials used for making "unground" molded glass lenses (a process that eliminates the grinding and polishing production operations) are included, the percentage of imported optical glass used jumps to almost 70 percent.

The primary foreign suppliers of optical glass are Japan (Hoya and Ohara) and West Germany (Schott). All firms that purchased raw optical glass (rather than pressings) used some imported bulk glass from one or more of these sources, and did so because a domestic source was not available or was inadequate. Infrared raw materials were imported by all four domestic firms competing in the infrared optics market, mainly from Europe (France, West Germany and Belgium). The reasons given for importing were price and lack of adequate domestic sources.

Machinery, equipment and tools used in optics production were by far the most common items mentioned as being produced offshore. The main sources of these items (including diamond tools, generators, polishers, grinders, profilometers, etc.) were Japan, West Germany, and England. Reasons given by respondents for utilizing imported equipment were better quality and inadequate domestic supply.

Another item mentioned by several firms was polishing compound, imported from France. Lastly, two firms listed imported finished optics -- lenses and prisms -- purchased from Taiwan, Japan, and Singapore. As might be expected, the primary reason for importing these items was their lower cost.

All optical materials suppliers import a wide range of metals and oxides. For metals, imports ranged from a low of 40 percent to a high of 100 percent for individual firms. The reasons given for using imported metals were lower prices and availability. The most common item mentioned was Selenium metal, imported from Japan. Other examples are Lanthanum Oxide from France, and Barium Nitrate from the Peoples Republic of China.

In general, imports are used because of availability (4 mentions), price (3 mentions) and sole source (3 mentions). Several precision optics firms have set up subsidiaries/affiliates in the Far East in an attempt to reduce costs and increase competitiveness. Other firms do not have formal arrangements, but rely on imports from these countries to reduce their costs. Half of the optical materials respondents had affiliates overseas, all in Europe.

2.8 INDUSTRY COMPETITIVENESS

2.8.1 International Competitive Comparisons

The surveyed firms were asked to compare various competitive factors between optics industries in the United States and other leading countries. In both the precision optics and optical material sectors, U.S. firms rated themselves most competitive in the technology area (engineering, design and quality) and least competitive in costs and prices. The Far East was rated just the opposite, as most competitive in costs and least competitive in technical capabilities. European firms were not viewed as a competitive problem.

The technical capabilities of Japan are increasing but currently estimated to be about 80 to 90 percent of those of U.S. producers. Singapore's comparative capabilities were rated at about 60 percent, and Mainland China's at only about 35 percent. Western European producers are considered roughly equivalent to U.S. firms in technical capabilities.

Wage scales in the Far East are much lower than in either the United States or Europe. About 70 to 75 percent of the total cost of optical element production is "people cost". This is an extraordinarily high percentage compared with most other manufacturing industries and underlies the massive displacement of both American and European producers from the high volume optical markets in the last decade by Far East producers.

Hourly wage scales by country in 1985 were approximately as follows: United States, $8.00; Japan, $6.00; Singapore, $2.20; Taiwan, $2.00; Korea, $1.80; India, $.65; and Mainland China, $.15.

However, other factors besides low labor rates can also influence the competitive position of these countries and the markets they compete in. Work patterns may not be as developed in countries like Singapore and China as they are in Japan and the United States. Also, management and supervision may not be as adept which affects both production efficiency and the quality of finished products. Moreover, very low wage rates make it harder to justify investment in sophisticated equipment. It is, therefore, difficult to envision these countries challenging the U.S. in the high end of the market in the near future. On balance, however, the low labor rates enable these countries to make standard type optical components from one half to one third the cost of equivalent American made products.

As for the material producers, the U.S. infrared material producers are competitive with any producers in the world. Far East producers have not entered the infrared market as yet.

However, several competitive problems exist in the optical glass and preform markets. An estimated 400 to 500 optical glass blends are in use. Schott Glass Technologies has the capability to produce all of these which is an enormous competitive strength. However, only about 18 percent of these blends constitute 90 percent of total world-wide consumption. Schott has largely been eliminated from these higher volume markets by Hoya and Ohara of Japan, which do not produce as many types of glass, preferring to concentrate their efforts on the high volume types.

The following tables show the surveyed firms aggregated estimates comparing the listed competitive factors between leading countries.

PRECISION OPTICS INDUSTRY

Competitive Factor	United States	Japan	West Germany	Singapore
Price	3	2	4	1
Quality	1	3	2	4
Input costs:				
labor	4	2	3	1
capital	3	1	2	4
optical materials	3	1	2	4
other (specify)	3	1	3	2
Delivery (lead time)	1	2	3	4
Follow-up service	1	2	3	4
Design capability	1	3	2	4
Engineering capability	1	3	2	4
Customer satisfaction	1	2	2	3
Trade barriers	5	3	2	4
Government supports	4	1	3	2

OPTICAL MATERIALS INDUSTRY

Competitive Factor	United States	Japan	West Germany	Belgium
Price	3	2	4	1
Quality	1	3	4	2
Input costs:				
labor	2	1	1	1
capital	3	2	2	1
other (specify)	3	2	1	
Delivery (lead time)	1	2	2	2
Follow-up service	1	2	2	2
Research capability	2	1	3	4
Customer satisfaction	2	3	4	1
Trade barriers	3	1	1	2
Government supports	3	1	2	4

Note: One means most competitive, five means least competitive.

2.8.2 Competitive Prospects

In the industry surveys the companies were asked to comment on their competitive prospects over the next five years. On balance the optical element producers view their prospects as improving somewhat. In the last ten years most of the firms have reoriented their production into the higher value precision optical categories which are less impacted by foreign competition. This reorientation is evidenced by their stepped-up purchases of sophisticated production and testing equipment in recent years. In addition, profits have improved for several companies as they have taken actions to reduce overhead and production costs. These actions include establishing lower cost foreign facilities to provide unfinished parts as well as using greater amounts of lower cost imported equipment and raw materials.

Two firms see their competitive prospects as improving greatly, one because of rapid growth in its commercial markets (laser printers) and the other because of investments in improved, more efficient manufacturing equipment and procedures. (Note: Domestic laser printer producers are currently losing market share to foreign suppliers.)

One optical element producer indicated with some caution that its competitive prospects would stay about the same and another said its prospects would decline. The former noted that technology is being transferred to the Far East, in part because of offshore procurement by the U.S. Government. The other firm stated the technology capabilities in all countries are gaining on the U.S. This firm noted that technical capabilities have been our major competitive strength, but could be undermined in the near future as additional foreign firms seek to participate in the higher end of the market.

Among the optical material producers the competitive outlook is mixed. The infrared material market looks the most promising. Two of the infrared firms said their prospects will improve greatly in the next five years. One of these cited its involvement in new advanced materials research that will lead to new products. The other recently formed a joint venture with a foreign firm that will allow market growth utilizing domestic production capacity. Another firm in the infrared material market reported competitive prospects would improve somewhat, depending on currency exchange fluctuations, while a fourth competitor in this market said prospects would stay about the same. One firm noted that infrared raw material costs are lower in the United States than in Europe which gives U.S. firms a slight advantage.

The optical glass sector presents an entirely different picture. One glass melter permanently shut down its plant in 1986 because low volume production could not justify accepting continued losses. The competitive prospects for the one remaining glass melter and the one remaining glass preform producer are not good. These firms have been priced out of the high volume optical glass markets which are critical to efficient operations. The uncertainty of U.S. Government funding for various programs and the continued (alleged) predatory pricing practices of Japanese firms jeopardize the survival of these firms.

2.8.3 Offset Agreements

An area of limited but growing concern to optical element and optical material producers was the increasing demand for offsets by foreign governments when purchasing U.S. defense and related equipment. Offsets are defined as a range of industrial and commercial compensation practices mandated, directly or indirectly, by a purchasing government or company. Offset agreements include coproduction, licensed production, subcontractor production, overseas investment, investment and countertrade.

Two precision optics producers cited specific examples of lost element sales due to offset agreements between the United States and the Governments of Canada and Switzerland for anti-tank and air-to-ground missiles. In both cases, the U.S. optics producer is the supplier of optical elements for Defense Department consumption in these particular missiles. However, as part of the offset agreement, both U.S. producers found their elements displaced by Swiss and Canadian produced-optical elements.

Similarly, three optical material suppliers surveyed complained that offset agreements were indirectly affecting them by taking away business from their customer base (precision optics firm) which in turn reduced the sales of these three firms. Instead, raw material needs were being supplied by local country material suppliers directly to the local country optical producers.

With the commercial optical base already severely eroded, offset agreements involving defense precision optics serve to further aggravate an already deteriorating situation. Moreover, the technologies and production capabilities involved in these offsets are transferred to foreign firms which can negatively impact long-term U.S. competitiveness.

2.8.4 Actions Companies Have Taken to Increase Competitiveness

The optical element firms have responded to international competitive pressures by investing in automation and other more productive equipment. They have also reduced overhead, increased the skill level of their work force, enhanced their production capabilities and consolidated certain operations. In addition, several firms have established foreign subsidiaries in the Far East to take advantage of prevailing lower labor rates in that area. The result of these on going actions has been a shift by the industry into the more sophisticated end of the optical element market, the avoidance of head-to-head competition with foreign competitors, and in a leaner, more versatile group of companies.

As mentioned in Laser Focus magazine in its November 1986 issue, the companies are finding ways to survive. The "ingredients for success" suggested in that article include: (1) offer high-quality products that imports do not compete with, (2) provide fast, dependable service so as not to delay customer's important projects, (3) manufacture as efficiently as possible using automated equipment and computer assisted manufacturing processes, (4) find a "niche" and become the best at what you do, and (5) work hard, persevere, and be lucky.

The surveyed optical element producers appear to be responding in these areas. However, perhaps the larger and more ominous problem for the industry is the continuing and massive migration offshore of end markets, such as cameras, microscopes and telescopes that contain optical elements. U.S. firms may not even get an opportunity to bid on orders, once they move offshore.

The optical material companies have stepped up research to develop new products, imported basic material in an effort to lower costs and formed joint ventures to acquire technology. Schott Glass Technologies independently developed a unique capability to continuously produce glass types which heretofore could only be melted discontinuously.

2.8.5 U.S. Government Actions To Improve Industry's Competitiveness

Seven out of the ten optics plants surveyed believe that U.S. Government support is necessary to improve their competitive position. They believe that the present international optics market is biased in favor of foreign firms, particularly those in Japan, because of unfair trade practices, and strong foreign government supports, combined with a perceived lack of concern by the U.S. Government.

Most precision optics firms support implementation of a Federal Acquisition Regulation requiring use of domestically produced optics in military applications. It is thought that a FAR will do much to preserve the domestic optics base and reduce dependency on foreign suppliers. Other Government actions or support programs suggested include: reforming the tax code to encourage investment in new equipment and R&D, revision of U.S. trade laws, adopting retaliatory trade practices, and funding training programs for opticians and other necessary personnel.

Also, most firms believe that DoD modernization programs (IMIP, Tech Mod, etc.) could be very beneficial to the optics industry, although many were unaware that these programs existed.

2.8.6 Age of Equipment

The age of equipment may have a bearing on the competitiveness of U.S. firms because as it ages it may become both technically obsolete and more difficult to maintain. In the survey we asked the companies to identify the numbers and ages of selected equipment and followed this up with a discussion with several firms.

Survey results show that 74 percent of the capital equipment used to produce optical elements is ten or more years old, and 44 percent is more than 20 years old. Japanese equipment of the same types, for comparison purposes, is believed to be somewhat younger than American equipment. Although new high speed grinding and polishing machinery could substantially increase productivity, firms would encounter delays both in their actual use and in added start up costs associated with retraining employees currently accustomed to older equipment. However, it is estimated that this new equipment, once in full operation, could increase industry's productivity by as much as 50 percent.

In general, the average life of machines (polishing, grinding) can be as long as 30 or 35 years, depending on maintenance and spare part availability. Producers noted that older equipment could be a constraint during a surge or mobilization because it may break down more frequently and spare parts are often more difficult to obtain. Expanded production in a surge or mobilization using older equipment would require more labor than would be needed with newer equipment. This could be an additional problem with the expected shortage of opticians as well as other critical occupations.

PRECISION OPTICS INDUSTRY - AGE OF CAPITAL EQUIPMENT

	0-4 Yrs.	5-9 Yrs.	10-19 Yrs.	20 Yrs. & Up
Optical Sawing and Shaping Machines	13	17	32	22
Curve Generating Machines (Ring Tool)	108	17	16	35
Spindles (Lap Machines)	172	217	309	388
Centering and Edging Machines	8	19	23	43
Interferometers	26	91	11	2
Diamond Point Turning Machines	5	1	0	0
Vacuum Coating Chambers	12	22	22	10
Total	344	384	413	500

OPTICAL MATERIALS INDUSTRY - AGE OF CAPITAL EQUIPMENT

	0-4 Yrs.	5-9 Yrs.	10-19 Yrs.	20 Yrs. & Up
Furnaces	12	11	40	15
Annealing Ovens	5	15	28	20
Vacuum Chambers	4	1	3	1
Finishing Equipment	3			20
Grinding & Sawing Equipment	4	2	10	11
Total	28	29	81	67

Older machinery that runs at slower speeds may have advantages over high speed equipment in low volume production. However, newer equipment with computer assisted tooling adjustments and production monitoring have made much of this older equipment technically obsolete. At the same time, newer equipment is expensive and it may be difficult for many optics firms to justify the expenditure in the current uncertain economic environment.

However, some firms are actively replacing older equipment. One producer reported a $500,000 budget for new high speed equipment. This same producer also has constructed specialized machinery in-house that may confer unique capabilities and/or provide a competitive "niche" that established equipment vendors could not do economically. However, design time to build in-house machines can be expensive. While most firms build or modify some of their equipment in-house to fill special needs, only a few producers have the genuine capability to develop or build their own equipment from the ground up.

2.9 OTHER FACTORS

2.9.1 Strategic Defense Initiative (SDI)

During the '85 Army review of Precision Optics, the question arose as to how much of an increase in requirements for optics could be expected from the SDI. Such a program which relies heavily on lasers and sensor technology will be a significant user of Optics. In an attempt to obtain quantifiable data, visits to the SDIO were arranged. Unfortunately, because deployment of any SDI system is many years away and with the program only in a research phase, quantities of required Optics could not be identified with any significant degree of confidence. Therefore, it was decided not to include SDI requirements with the rest of DOD's, but to recognize that a significant increase in requirements for optics would occur if SDI deployment takes place.

2.9.2 Advanced Technology

Since one of the key ingredients to the competitive edge of the Far East producer is the lower pay scale for labor, the obvious remedy for domestic industry is to automate the process as much as possible. Unfortunately, since optics is still somewhat in the realm of a "Black Art", automation is extremely difficult. The 1985 Army (AMC) report describes on-going efforts that attempt to foster automation. Other advanced technologies such as molded glass are also discussed.

A new program for the development of improved optical performance technical resources is being proposed by the Defense Advance Research Projects Agency (DARPA). Its objective is to develop the technology for manufacture of high performance optical systems. The three program elements are design, glass manufacturing, and component surfacing. Some of the areas being proposed for investigation are artificial intelligence aids to design, sol-gel forming of glass, and plasma or ion stream finishing using computer controlled machinery.

The bottom line is that the industry is still using some of the same basic methods developed over a half century ago; any radical change in utilized technology is many years away from adoption, primarily due to declining firm profitability which limits the firm's ability to afford new technology when available.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

The following seven conclusions can be drawn based on the findings of the JPOTG:

a. Without the bulk of DOD procurements the domestic Precision Optics industry will continue to decline.

b. Based on current trends, foreign producers will capture an increasing share of the DOD market

c. Further reductions in domestic production capacity threaten the national security.

d. Available trade and economic corrective measures have not been fully investigated.

e. Domestic producers are not cost competitive with the low labor rates that prevail in the Far East.

f. Shortages of trained opticians would hinder a surge or mobilization.

g. Additional funds from the Department of Defense for optics will be required.

The domestic Optical Industry has declined dramatically in recent years because of foreign competition in both optical elements and element end-markets. The resulting deterioration in surge and mobilization capabilities can threaten our national security.

3.2 RECOMMENDATIONS

The fact that this study, which incorporates the requirements of the three services, has reached the same basic conclusions as the '84 AD HOC and the '85 Army review, affirms that action is needed to reduce the continued erosion of this critical industry. Following a review of many options, two major recommendations were chosen as the best means to correct the national security problems over both the short and long term for the Precision Optics and Optical Material Industries.

The first recommendation is the implementation of a Federal Acquisition Regulation (FAR) clause. The scope of this FAR clause and how it compares to earlier proposals can be found in the appendices. The short term benefits are that it will:

1) stop the incursion of foreign producers into the defense market
2) encourage domestic capital investment and capacity expansion
3) provide incentives for technology enhancement and development

In the long term, the FAR clause will contribute to the restoration of a viable surge/mobilization protection base and contribute indirectly to the re-establishment of the commercial base.

Implementation of the FAR will of course generate some negative factors, but this must be considered on balance with the national security implications of losing the entire optical industry production base. One obvious consequence is the increase in cost for domestic optics. Even though competition within the U.S. will help reduce this burden, domestic manufacturing can be expected to cost the systems managers (Army, Navy, Air Force) between $10 and $20 million per year.

The second recommendation is for an assessment of trade and economic factors impacting this industry by the Department of Commerce, as these are questions which fall primarily under the jurisdiction of DOC. Accordingly, the second major recommendation is to request the Commerce Department to assess the trade and economic factors impacting this critical industry and formulate options to rectify the situation.

A final recommendation is that the Services place more emphasis on technology programs which foster optical fabrication advancement. As the new technology mentioned in section 2.9.3. matures, the program managers should require their contractors to utilize it as much as possible.

Since it is not expected that the actions recommended will result in any immediate increase in domestic capacity, a few years should elapse before any new review should be undertaken.

The findings, conclusions, and recommendations presented above have been coordinated and concurred in by the Four Commands of the Joint Logistics Commanders and the Department of Commerce, International Trade Administration.

APPENDIX A

Description of the Precision Optics Production Process

Description of the Manufacturing Process

The manufacture of optical elements involves three broadly defined stages of production. The finishing or third stage was the major focus of this assessment. This is the most difficult and expensive stage of production, representing between 80 and 90 percent of the value added of finished optical elements. The finishing stage is preceded by raw glass (stage one) and preform production (stage two). In raw glass production, raw materials are heated and blended together in a closely controlled furnace. Typical raw materials include silica, oxides and rare earth compounds. In the case of visible glass, the heated mixture is used to form molten glass. The precise blend depends on the specifications required for the final glass. The molten glass is annealed and cooled, and formed into blocks, slabs or gobs.

The second stage begins by annealing the blocks, slabs or gobs. The material is then cut or sliced into pieces which are heated and pressed in molds into sizes approximating the finished component. This reduces the time required to generate the required precision component. These raw glass products are referred to as pressings, blanks or preforms.

Both the first and second stages are capital intensive operations that require volume production to achieve cost economies. Only one major firm, Schott Glass Technologies in Duryea, Pennsylvania currently produces the raw glass in the United States and only one firm, United Lens Company in Southbridge, Massachusetts makes the preforms. The Department of Commerce survey revealed that neither of these firms is operating profitably at this time because of dwindling domestic markets, increasing foreign competition, and low rates of capacity utilization. In the case of non-visible optics, several domestic firms produce the raw material and blanks for infrared and ultraviolet optical components.

The third stage of optical component production is the finishing stage. The finishing process is very labor intensive and is sometimes referred to as a "black art" because of special skills required of the opticians. When preforms (often flat discs) are received they are ground to near net shape (generated) by cutting wheels made of brass impregnated with industrial diamonds. In generating a lens, the cutting wheel will grind the preform to within two hundredths of an inch of final thickness and one tenth of an inch of its final diameter. After generation the workpiece is first rough ground, then medium and fine ground before polishing and lapping to its finished dimensions. Very little stock is removed during the grinding and polishing operations, ranging between only five to eight thousandths of an inch off each face. The edges are then trimmed to bring the diameter to design specifications and finally the optical element is coated with Magnesium Flouride or some other substances to enhance or reduce reflections, improve corrosion and/or scratch resistance, eliminate fogging, or endow the element with some other special quality. The coating operation is extremely capital intensive requiring expensive equipment and processes. Coating is very important to military applications. Department of Defense requirements are currently the major driving force for advances in coating technology in terms of both material formulations and machinery capabilities.

After production of the optical element is completed, the element is then assembled into final product. This is also a labor intensive operation which utilizes special fixtures and tooling. All components (optical, mechanical and electrical) must be interfaced, inspected and tested as final assemblies. (This final stage was not analyzed for this investigation.)

APPENDIX B

Precision Optics and Optical Material Industry Surveys

Form ITA-9055
(9-86)

U.S. Department of Commerce
International Trade Administration

OMB Approval Not
Required: less than
ten respondents

NATIONAL SECURITY ASSESSMENT OF PRECISION OPTICS INDUSTRY

THIS REPORT IS REQUIRED BY LAW

This report is required by law (50 U.S.C. App. Sec. 2155). Failure to report can result in a maximum fine of $1,000 or imprisonment up to one year, or both. Information furnished herewith is deemed confidential and will not be published or disclosed except in accordance with Section 705 of the Defense Production Act of 1950, as amended (50 U.S.C. App. Sec. 2155).

General Instructions

1. It is not our desire to impose an unreasonable burden on any respondent. IF INFORMATION IS NOT READILY AVAILABLE FROM YOUR RECORDS IN EXACTLY THE FORM REQUESTED, FURNISH ESTIMATES AND DESIGNATE BY THE LETTER "E". Any necessary comments or explanations should be supplied in the space provided or on separate sheets attached to this questionnaire. Ensure that you reference the proper question if you use extra sheets. If any answer is "none", please indicate.
2. Report calendar year data, unless otherwise specified in a particular question. Please complete Parts II and III separately for each of your establishments that produce precision optics in the United States. Please make photocopies of forms if additional copies are needed. For Parts I, IV and V, firms operating more than one establishment may combine the data for all establishments into a single report.
3. In addition to the original report form to be returned to us, a file copy is enclosed for your records. You are not legally required to fill out or retain this file copy. While it would be a convenience to the Government for a file copy to be made and retained for reference purposes, no assurances can be provided that file copies will be exempt from compulsory examination in the future.
4. Questions related to the questionnaire should be directed to Mr. Robert O'Shaughnessy, Physicist, (201) 724-6223, Department of the Army, Mr. Rod White, General Engineer, (309) 782-6226, Department of the Army, or Mr. John Tucker, Industry Analyst, (202) 377-3795, Department of Commerce.
5. Before returning your completed questionnaire, be sure to sign the certification and identify the person and phone number to contact your firm.

7. Return completed questionnaire by October 24, 1986 to:

U.S. Department of Commerce
International Trade Administration
Office of Industrial Resource Administration
Attn: Brad Botwin, Program Manager for
Industrial Capabilities, Room H3876
Washington, D.C. 20230

DEFINITIONS

BOTTLENECK—During a production expansion, the production process, operation or procedure, or material or labor requirement within your manufacturing establishment that would ultimately prevent or delay increased production.

CRITICAL OCCUPATIONS—Includes occupations for which you anticipate a potential shortage of qualified personnel during surge or mobilization. In general, this would include skilled occupations that require an extended training period.

ESTABLISHMENT—All facilities in which precision optics are produced. Includes auxiliary facilities operated in conjunction with (whether or not physically separate from) such production facilities. Does not include wholly owned distribution facilities.

FIRM—An individual proprietorship, partnership, joint venture, association, corporation (including any subsidiary corporation in which more than 50 percent of the outstanding voting stock is owned), business trust, cooperative, trustees in bankruptcy, or receivers under decree of any court, owning or controlling one or more establishments as defined above.

INDUSTRIAL MODERNIZATION INCENTIVE PROGRAM (IMIP)—IMIP is a joint venture between Government and industry to reduce weapon system acquisition cost through the implementation of modern manufacturing processes and increased or accelerated capital investments. IMIP is formalized through a contractual business agreement providing Government incentives for contractor capital investments.

MANUFACTURING TECHNOLOGY (MANTECH)—Any action which has as its objective, 1) the timely establishment or improvement of the manufacturing processes, techniques, or equipment required to support current and projected programs, and 2) the assurance of the ability to produce, reduce lead time, ensure economic availability of end items, reduce costs, increase efficiency, improve reliability, or to enhance safety and anti-pollution measures.

MOBILIZATION PRODUCTION CAPABILITY—The maximum realistic increase of sustainable defense production a manufacturing establishment can achieve in the 12 month period following a declared national emergency. Report achievable increase in defense production at the end of 6 months, 12 months, and 24 months in Part II of the questionnaire. Non-Defense production limited to 25% of 1985 peacetime levels. Government financial assistance and prioritization of construction materials and outfitting equipment is available. Your existing manufacturing buildings may be enlarged, new buildings constructed or existing buildings currently used by you for non-manufacturing purposes may be converted into manufacturing facilities, and plant equipment acquired. Consider critical labor skills to operate at maximum sustained production levels. Minimum defense requirement is 4X your average monthly defense production in 1985.

OFFSET AGREEMENTS—In international trade a range of industrial and commercial compensation practices when mandated, directly or indirectly, by a purchasing government or company as a condition of purchase. Offsets include co-production, licensed production, subcontractor production, overseas investment, technology transfer, and countertrade.

OPTICIANS—Technicians trained to grind, polish, and test optical components (e.g. lenses, mirrors, prisms, and windows) and assemble these components into an optical system. Training takes place under the supervision of a master optician with many years of experience. Training can be either on the job or formal training.

PRACTICAL CAPACITY—Sometimes referred to as engineering or design capacity, this is the greatest level of output this plant can achieve within the framework of a realistic work pattern. In estimating practical capacity, please take into account the following considerations:

1. Under most circumstances assume your 1985 product mix. If no production took place in 1985 of a particular item or group of items which you have, or will have the capability to produce and can anticipate receiving orders for in the future, include a reasonable quantity as part of your 1985 product mix.
2. Consider only the machinery and equipment in place and ready to operate. Do not consider facilities which have been inoperative for a long period of time and, therefore, require extensive reconditioning before they can be made operative.
3. Take into account the additional downtime for maintenance, repair, or clean-up which would be required as you move from current operations to full capacity.
4. Do not consider overtime pay, added costs for materials, or other costs to be limiting factors in setting capacity.
5. Although it may be possible to expand plant output by using productive facilities outside of the plant, such as by contracting out subassembly work, do not assume the use of such outside facilities in greater proportion than has been characteristic of your operations.

PRECISION OPTICS—Elements made by grinding, polishing, turning or molding material to be used to transmit, refract or reflect light in the ultra-violet (.1 to.4 micrometers), visible (.4 to .7 micrometers), near infrared (.7 to 3.0 micrometers), and/or infrared (3.0 to 16.0 micrometers) spectra. Excluded are ophthalmic elements, molded plastics, fiber optics, gratings, faceplates for tubes, ordinary window glass, windshields, and canopies.

PRODUCTION WORKERS—Persons, up through the line supervisor level, engaged in fabricating, processing, assembling, inspecting, receiving, storing, handling, packing, warehousing, or shipping. In addition, persons engaged in supporting activities such as maintenance, repair, product development, auxiliary production for your firm's own use, record keeping, and other services closely associated with production operations at your firm. Employees above the working supervisor level are excluded from this item.

REPAIR TECHNOLOGY (REPTECH)—Projects which improve DOD overhaul and repair operations.

RESEARCH AND DEVELOPMENT—Research and development includes basic and applied research in the sciences and in engineering, and design and development of prototype products and processes. For the purposes of this questionnaire, research and development includes activities carried on by persons trained, either formally or by experience, in the physical sciences including related engineering, if the purpose of such activity is to do one or more of the following things:

1. Pursue a planned search for new knowledge, whether or not the search has reference to a specific application.
2. Apply existing knowledge to problems involved in the creation of a new product or process, including work required to evaluate possible uses.
3. Apply existing knowledge to problems involved in the improvement of a present product or process.

SCIENTISTS AND ENGINEERS—Persons engaged in research and development work or production operations that have at least a four-year college education in the physical sciences or engineering.

SHIPMENTS—Report unit and dollar values of domestically produced precision optics shipped by your firm during the reporting period for each category for questions in Part 1. Such shipments should include inter-plant and intra-plant transfers, but should exclude shipments of products produced by other manufacturers for resale under your brand name. Do not adjust for returned shipments. Estimate the defense portion for unit and dollar values where requested at the end of each product grouping in Part 1. The defense portion of your business may be identified by those purchase orders bearing a DO or DX rating and/or a contract number from the Department of Defense, NRC, CIA, FAA, or NASA, as well as the orders of your customers whom you could identify as producing products for defense purposes, and items tested and certified to military specifications shipped to qualified distributors.

SINGLE SOURCE—An item currently being purchased from one source; other sources may be available, however, they may not be qualified or were not considered.

SOLE SOURCE—An item being purchased from one source, and no other production capability exists.

SURGE PRODUCTION CAPABILITY—The maximum sustainable level of defense production that can be achieved within an existing establishment by the end of the 6 month period immediately following surge day while maintaining non-defense deliveries. Report achievable defense production quantities of precision optical components at the end of 3 months, and 6 months in Part II of the questionnaire. Procurement actions for additional materials to sustain surge production levels will be initiated on surge day. Existing idle equipment may be activated as is, repaired, or upgraded and brought into service, or used equipment may be purchased and installed if possible within the 6 month time frame. Labor may be hired and trained in numbers sufficient to operate around the clock and weekends allowing for necessary equipment maintenance and downtime. Minimum defense requirement is 2X your average monthly defense production in 1985.

TECHNOLOGY MODERNIZATION (TECH MOD)—The coupling of modernization with the implementation of advanced manufacturing technology by providing incentives for contractor and subcontractor capitalization.

UNITED STATES—The term "United States" includes the fifty States, Puerto Rico, the District of Columbia, and the Virgin Islands.

PART I

FIRM IDENTIFICATION

1. Name and address of your firm or corporate division.

____
____
____

If your firm is wholly or partly owned by another firm, indicate the name and address of the parent firm and extent of ownership.

____
____
____

2. Identify the location of your precision optics manufacturing establishment(s) in the United States. (See definition of precision optics.)

	Locality	State	Zip Code
(a)			
(b)			
(c)			

3. Identify any U.S. manufacturing establishments in which you ceased precision optics production operations since 1980 and the reason production was stopped.

____
____
____
____
____
____
____
____

PART I - A. PRECISION OPTICS SHIPMENTS (UNITS)

Enter total unit and estimated defense share of shipments of precision optics as indicated below (i.e., for all manufacturing establishments). Count each optical component of a shipped assembly as a separate unit. (See definition of shipments.)

1. Visible Optics	1981	1982	1983	1984	1985
a. Lenses					
(1) Small (under .5" O.D.)	____	____	____	____	____
(2) Medium (.5 to 2" O.D.)	____	____	____	____	____
(3) Large (2 to 8" O.D.)	____	____	____	____	____
(4) Very Large (over 8" O.D.)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____
b. Prisms					
(1) Small (under .25 sq.in. clear aperture area)	____	____	____	____	____
(2) Medium (.25 to 4 sq.in. clear aperture area)	____	____	____	____	____
(3) Large (4 to 64 sq.in clear aperture area)	____	____	____	____	____
(4) Very Large (over 64 sq.in. clear aperture area)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____
c. Mirrors (including non-glass substrates)					
(1) Small (under .25 sq.in. surface area)	____	____	____	____	____
(2) Medium (.25 to 4 sq.in. surface area)	____	____	____	____	____
(3) Large (4 to 64 sq.in. surface area)	____	____	____	____	____
(4) Very Large (over 64 sq.in. surface area)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____

	1981	1982	1983	1984	1985
d. Other Flats					
(1) Small (under .25 sq.in. clear aperture area)					
(2) Medium (.25 to 4 sq.in. clear aperture area)					
(3) Large (4 to 64 sq.in. clear aperture area)					
(4) Very Large (over 64 sq.in. clear aperture area)					
Estimated Defense Share (%)					

2. <u>Infrared Material Optics</u>

	1981	1982	1983	1984	1985
a. Lenses					
(1) Small (under 1" O.D.)					
(2) Medium (under 2.5" O.D.)					
(3) Large (2.5" to 6" O.D.)					
(4) Very Large (6" to 12" O.D.)					
Estimated Defense Share (%)					
b. Windows					
(1) Small (under 1" O.D., under 0.080" thick)					
(2) Medium (under 2.5" O.D., under 0.200" thick)					
(3) Large (under 6" O.D., under 0.500" thick)					
(4) Very Large (6" to 12" O.D. under 1.50" thick)					
Estimated Defense Share (%)					
b. Prisms					
(1) Small (under .50 sq.in. clear aperture area)					

	1981	1982	1983	1984	1985
(2) Medium (.50 to 1 sq.in. clear aperture area)	___	___	___	___	___
(3) Large (1 to 2 sq.in. clear aperture area)	___	___	___	___	___
(4) Very Large (over 2 sq.in. clear aperture area)	___	___	___	___	___
Estimated Defense Share (%)	___	___	___	___	___

3. <u>Ultraviolet</u>

a. Lenses

(1) Small (under 0.5" O.D.)	___	___	___	___	___
(2) Medium (0.5 to 1" O.D.)	___	___	___	___	___
(3) Large (1" to 3" O.D.)	___	___	___	___	___
(4) Very Large (over 3" O.D.)	___	___	___	___	___
Estimated Defense Share (%)	___	___	___	___	___

b. Prisms

(1) Small (under .25 sq.in.)	___	___	___	___	___
(2) Medium (0.25 to 4 sq.in.)	___	___	___	___	___
(3) Large (4 to 6 sq.in.)	___	___	___	___	___
(4) Very Large (over 6 sq.in.)	___	___	___	___	___
Estimated Defense Share (%)	___	___	___	___	___

c. Windows

(1) Small (under 0.5" O.D.)	___	___	___	___	___
(2) Medium (under 1" O.D.)	___	___	___	___	___
(3) Large (under 3" O.D.)	___	___	___	___	___
(4) Very Large (over 3" O.D.)	___	___	___	___	___
Estimated Defense Share (%)	___	___	___	___	___

PART I - B. PRECISION OPTICS SHIPMENTS (DOLLARS)

Enter total dollar and estimated defense share of shipments of precision optics as indicated below (i.e., for all manufacturing establishments). Count each optical component of a shipped assembly as a separate unit. (See definition of shipments.)

1. Visible Optics	1981	1982	1983	1984	1985
a. Lenses					
(1) Small (under .5" O.D.)	____	____	____	____	____
(2) Medium (.5 to 2" O.D.)	____	____	____	____	____
(3) Large (2 to 8" O.D.)	____	____	____	____	____
(4) Very Large (over 8" O.D.)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____
b. Prisms					
(1) Small (under .25 sq.in. clear aperture area)	____	____	____	____	____
(2) Medium (.25 to 4 sq.in. clear aperture area)	____	____	____	____	____
(3) Large (4 to 64 sq.in clear aperture area)	____	____	____	____	____
(4) Very Large (over 64 sq.in. clear aperture area)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____
c. Mirrors (including non-glass substrates)					
(1) Small (under .25 sq.in. surface area)	____	____	____	____	____
(2) Medium (.25 to 4 sq.in. surface area)	____	____	____	____	____
(3) Large (4 to 64 sq.in. surface area)	____	____	____	____	____
(4) Very Large (over 64 sq.in. surface area)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____

	1981	1982	1983	1984	1985
d. Other Flats					
(1) Small (under .25 sq.in. clear aperture area)	____	____	____	____	____
(2) Medium (.25 to 4 sq.in. clear aperture area)	____	____	____	____	____
(3) Large (4 to 64 sq.in. clear aperture area)	____	____	____	____	____
(4) Very Large (over 64 sq.in. clear aperture area)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____

2. <u>Infrared Material Optics</u>

	1981	1982	1983	1984	1985
a. Lenses					
(1) Small (under 1" O.D.)	____	____	____	____	____
(2) Medium (under 2.5" O.D.)	____	____	____	____	____
(3) Large (2.5" to 6" O.D.)	____	____	____	____	____
(4) Very Large (6" to 12" O.D.)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____
b. Windows					
(1) Small (under 1" O.D., under 0.080" thick)	____	____	____	____	____
(2) Medium (under 2.5" O.D., under 0.200" thick)	____	____	____	____	____
(3) Large (under 6" O.D., under 0.500" thick)	____	____	____	____	____
(4) Very Large (6" to 12" O.D. under 1.50" thick)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____
b. Prisms					
(1) Small (under .50 sq.in. clear aperture area)	____	____	____	____	____

	1981	1982	1983	1984	1985
(2) Medium (.50 to 1 sq.in. clear aperture area)	____	____	____	____	____
(3) Large (1 to 2 sq.in. clear aperture area)	____	____	____	____	____
(4) Very Large (over 2 sq.in. clear aperture area)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____

3. <u>Ultraviolet</u>

a. Lenses

(1) Small (under 0.5" O.D.)	____	____	____	____	____
(2) Medium (0.5 to 1" O.D.)	____	____	____	____	____
(3) Large (1" to 3" O.D.)	____	____	____	____	____
(4) Very Large (over 3" O.D.)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____

b. Prisms

(1) Small (under .25 sq.in.)	____	____	____	____	____
(2) Medium (0.25 to 4 sq.in.)	____	____	____	____	____
(3) Large (4 to 6 sq.in.)	____	____	____	____	____
(4) Very Large (over 6 sq.in.)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____

c. Windows

(1) Small (under 0.5" O.D.)	____	____	____	____	____
(2) Medium (under 1" O.D.)	____	____	____	____	____
(3) Large (under 3" O.D.)	____	____	____	____	____
(4) Very Large (over 3" O.D.)	____	____	____	____	____
Estimated Defense Share (%)	____	____	____	____	____

PART II - A. PEACETIME CAPACITY
B. SURGE AND MOBILIZATION PRODUCTION CAPABILITIES
C. WORKFORCE

INSTRUCTIONS

- Complete Part II for each establishment that manufactures precision optics.
- Report calendar year data, unless otherwise specified.
- If information is not readily available from your records in exactly the form requested, furnish estimates and designate by the letter "E".
- Do not leave questions unanswered. Enter "none" where appropriate.
- Photocopy this section as necessary.

ESTABLISHMENT IDENTIFICATION

______ (Locality) ______ (State) ______ (Zip Code)

A. PEACETIME CAPACITY

1. What is your annual practical capacity in units for producing precision optics in the following size and spectral ranges? (See definition of practical capacity.)

Visible Optics

a. Lenses

(1) Small (under .5" O.D. ____

(2) Medium (.5 to 2" O.D.) ____

(3) Large (2 to 8" O.D.) ____

(4) Very Large (over 8" O.D.) ____

b. Prisms

(1) Small (under .25 sq.in. clear aperture area) ____

(2) Medium (.25 to 4 sq.in. clear aperture area) ____

(3) Large (4 to 64 sq.in clear aperture area) ____

(4) Very Large (over 64 sq.in. clear aperture area) ____

c. Mirrors (including non-glass substrates)

(1) Small (under .25 sq.in. surface area) ____

(2) Medium (.25 to 4 sq.in. surface area) ____

(3) Large (4 to 64 sq.in. surface area) ____

(4) Very Large (over 64 sq.in. surface area) ____

d. Other Flats

(1) Small (under .25 sq.in. clear aperture area) ____

(2) Medium (.25 to 4 sq.in. clear aperture area) ____

(3) Large (4 to 64 sq.in. clear aperture area) ____

(4) Very Large (over 64 sq.in. clear aperture area) ____

Infrared Material Optics

a. Lenses

(1) Small (under 1" O.D.) ____

(2) Medium (under 2.5" O.D.) ____

(3) Large (under 6" O.D.) ____

(4) Very Large (under 12" O.D.) ____

b. Windows

(1) Small (under 1" O.D., under 0.080 thick) ____

(2) Medium (1" to 2.5" O.D., under 0.200" thick) ____

(3) Large (under 6" O.D., under 0.500" thick) ____

(4) Very Large (under 12" O.D., under 1.50" thick) ____

c. Prisms

(1) Small (under .5 sq. in. clear aperture area) ____

(2) Medium (under .5 to 1 sq. in. clear aperture area) ____

(3) Large (1 to 2 sq. in. clear aperture area) ____

(4) Very Large (over 2 sq. in. clear aperture area) ____

Ultraviolet

a. Lenses

(1) Small (under 0.5" O.D) ____

(2) Medium (under 1" O.D.) ____

(3) Large (3" O.D.) ____

(4) Very Large (over 3" O.D.) ____

b. Windows

(1) Small (under 0.5") ____

(2) Medium (under 1") ____

(3) Large (under 3") ____

(4) Very Large (over 3") ____

c. Prisms

(1) Small (under .25 sq.in.) ____

(2) Medium (0.25 to 4 sq.in.) ____

(3) Large (4 to 6 sq.in.) ____

(4) Very Large Greater than 6 sq.in. ____

2. Enter below factors which would increase/decrease capacity figures given above. (e.g. material, length of production run, etc.)

____

____

____

3. a. What was this establishment's practical capacity utilization rate in percent in 1985?

   Practical Capacity Utilization: ____% 1985

   b. How long would it take to reach practical capacity from the 1985 rate indicated? (in weeks)

   ____ Weeks

4. CONVERTIBILITY: Disregarding production efficiency considerations, briefly discuss the convertibility of your <u>non-defense</u> production operations to defense production, and the problems that might arise in the conversion (e.g., acquire additional testing equipment, additional skilled labor, dollars, time, etc.).

____

____

____

____

____

____

____

____

5. LEAD TIMES:

a. During 1985, what was your average lead time (i.e., from receipt of order to delivery to customer) for:

Non-Defense Orders ________weeks   Defense Orders ________weeks

b. Regarding your longest lead time defense items list the type of optic (lens, prism, etc.), the average lead time during 1985, and describe how that lead time could be significantly shortened.

Type of Optic	1985 Average Lead Time	How to Shorten Lead Time

c. Are lead times increasing for:

Non-Defense Orders? yes ____, no ____

Defense Orders? yes ____, no ____

d. If lead times are increasing, what are the reasons?

____

____

____

____

____

B. SURGE AND MOBILIZATION PRODUCTION CAPABILITIES

1. SURGE PRODUCTION CAPABILITIES: Enter your precision optics surge production capability below. Use 1985's average monthly defense production for each optical category as your base production rate. IN ESTIMATING YOUR SURGE PRODUCTION CAPABILITY, ASSUME ANY OTHER DEFENSE PRODUCTION (i.e., non-precision optics) IN THIS ESTABLISHMENT IS ALSO SURGED. Maintain non-defense production at 1985 levels. (See definitions of surge production capability and shipments.)

Report Monthly Rates in Units

Size Range	1985's average monthly defense production rate (Units)	Surge rate at 3 months (Units)	Surge rate at 6 months (Units)
1. Visible Optics			
a. Lenses			
(1) Small (under .5" O.D.	______	______	______
(2) Medium (.5 to 2" O.D.)	______	______	______
(3) Large (2 to 8" O.D.)	______	______	______
(4) Very Large (over 8" O.D.)	______	______	______
b. Prisms			
(1) Small (under .25 sq.in. clear aperture area)	______	______	______
(2) Medium (.25 to 4 sq.in. clear aperture area)	______	______	______
(3) Large (4 to 64 sq.in clear aperture area)	______	______	______
(4) Very Large (over 64 sq.in. clear aperture area)	______	______	______
c. Mirrors (including non-glass substrates)			
(1) Small (under .25 sq.in. surface area)	______	______	______
(2) Medium (.25 to 4 sq.in. surface area)	______	______	______
(3) Large (4 to 64 sq.in. clear aperture area)	______	______	______
(4) Very Large (over 64 sq.in. clear aperture area)	______	______	______

Size Range	1985's average monthly defense production rate (Units)	Surge rate at 3 months (Units)	Surge rate at 6 months (Units)
d. Other Flats			
(1) Small (under .25 sq.in. clear aperture area)	______	______	______
(2) Medium (.25 to 4 sq.in. clear aperture area)	______	______	______
(3) Large (4 to 64 sq.in. clear aperture area)	______	______	______
(4) Very Large (over 64 sq.in. clear aperture area)	______	______	______
2. Infrared Material Optics			
a. Lenses			
(1) Small (under 1" O.D.)	______	______	______
(2) Medium (under 2.5" O.D.)	______	______	______
(3) Large (under 6" O.D.)	______	______	______
(4) Very Large (under 12" O.D.)	______	______	______
b. Windows			
(1) Small (under 1" O.D., under 0.080" thick)	______	______	______
(2) Medium (under 2.5" O.D., under 0.200" thick)	______	______	______
(3) Large (under 6" O.D., under 0.500" thick)	______	______	______
(4) Very Large (under 12" O.D. under 1.50" thick)	______	______	______
c. Prisms			
(1) Small (under .50 sq.in. clear aperture area)	______	______	______
(2) Medium (.50 to 1 sq.in. clear aperture area)	______	______	______

Size Range	1985's average monthly defense production rate (Units)	Surge rate at 3 months (Units)	Surge rate at 6 months (Units)
(3) Large (1 to 2 sq.in. clear aperture area)	______	______	______
(4) Very Large (over 2 sq.in. clear aperture area)	______	______	______
3. Ultraviolet			
a. Lenses			
(1) Small (under 0.5" O.D)	______	______	______
(2) Medium (under 1" O.D.)	______	______	______
(3) Large (3" O.D.)	______	______	______
(4) Very Large (over 3" O.D.)	______	______	______
b. Windows			
(1) Small (under 0.5" O.D.)	______	______	______
(2) Medium (under 1" O.D.)	______	______	______
(3) Large (under 3" O.D.)	______	______	______
(4) Very Large (over 3" O.D.)	______	______	______
c. Prisms			
(1) Small (under .25 sq.in.)	______	______	______
(2) Medium (0.25 to 4 sq.in.)	______	______	______
(3) Large (4 to 6 sq.in.)	______	______	______
(4) Very Large (over 6 sq.in.)	______	______	______

B. SURGE AND MOBILIZATION PRODUCTION CAPABILITIES

1. MOBILIZATION PRODUCTION CAPABILITIES: Enter your precision optics mobilization production capability below? Use 1985's average monthly defense production for each optical category as your base production rate. IN ESTIMATING YOUR MOBILIZATION PRODUCTION CAPABILITY, ASSUME ANY OTHER DEFENSE PRODUCTION IN THIS ESTABLISHMENT IS ALSO MOBILIZED. Non-defense production falls to 25 percent of 1985 levels. (See definition of mobilization production capability.)

	Report Monthly Rates in Units			
Size Range	1985's average monthly defense production rate (Units)	Mob rate at 6 months (Units)	Mob rate at 12 months (Units)	Mob rate at 24 months (Units)
1. Visible Optics				
a. Lenses				
(1) Small (under .5" O.D.	______	______	______	______
(2) Medium (.5 to 2" O.D.)	______	______	______	______
(3) Large (2 to 8" O.D.)	______	______	______	______
(4) Very Large (over 8" O.D.)	______	______	______	______
b. Prisms				
(1) Small (under .25 sq.in. clear aperture area)	______	______	______	______
(2) Medium (.25 to 4 sq.in. clear aperture area)	______	______	______	______
(3) Large (4 to 64 sq.in clear aperture area)	______	______	______	______
(4) Very Large (over 64 sq.in. clear aperture area)	______	______	______	______
c. Mirrors (including non-glass substrates)				
(1) Small (under .25 sq.in. surface area)	______	______	______	______
(2) Medium (.25 to 4 sq.in. surface area)	______	______	______	______
(3) Large (4 to 64 sq.in. clear aperture area)	______	______	______	______
(4) Very Large (over 64 sq.in. clear aperture area)	______	______	______	______

Size Range	1985's average monthly defense production rate (Units)	Mob rate at 6 months (Units)	Mob rate at 12 months (Units)	Mob rate at 24 months (Units)
d. Other Flats				
(1) Small (under .25 sq.in. clear aperture area)				
(2) Medium (.25 to 4 sq.in. clear aperture area)				
(3) Large (4 to 64 sq.in. clear aperture area)				
(4) Very Large (over 64 sq.in. clear aperture area)				
2. Infrared Material Optics				
a. Lenses				
(1) Small (under 1" O.D.)				
(2) Medium (under 2.5" O.D.)				
(3) Large (under 6" O.D.)				
(4) Very Large (under 12" O.D.)				
b. Windows				
(1) Small (under 1" O.D., under 0.080" thick)				
(2) Medium (under 2.5" O.D., under 0.200" thick)				
(3) Large (under 6" O.D., under 0.500" thick)				
(4) Very Large (under 12" O.D. under 1.50" thick)				
b. Prisms				
(1) Small (under .50 sq.in. clear aperture area)				
(2) Medium (.50 to 1 sq.in. clear aperture area)				

Size Range	1985's average monthly defense production rate (Units)	Mob rate at 6 months (Units)	Mob rate at 12 months (Units)	Mob rate at 24 months (Units)
(3) Large (1 to 2 sq.in. clear aperture area)	______	______	______	______
(4) Very Large (over 2 sq.in. clear aperture area)	______	______	______	______
3. Ultraviolet				
a. Lenses				
(1) Small (under 0.5" O.D)	______	______	______	______
(2) Medium (under 1" O.D.)	______	______	______	______
(3) Large (3" O.D.)	______	______	______	______
(4) Very Large (over 3" O.D.)	______	______	______	______
b. Prisms				
(1) Small (under .25 sq.in.)	______	______	______	______
(2) Medium (0.25 to 4 sq.in.)	______	______	______	______
(3) Large (4 to 6 sq.in.)	______	______	______	______
(4) Very Large (over 6 sq.in.)	______	______	______	______
c. Windows				
(1) Small (under 0.5" O.D.)	______	______	______	______
(2) Medium (under 1" O.D.)	______	______	______	______
(3) Large (under 3" O.D.)	______	______	______	______
(4) Very Large (over 3" O.D.)	______	______	______	______

SURGE AND MOBILIZATION BOTTLENECKS

1. SURGE BOTTLENECKS: List and rank the bottlenecks you envision would be encountered in a surge and the time and cost to correct. Rank bottlenecks in order of occurrence. If the answer is "none", please indicate. Please refer to definition of bottleneck.

Area of Occurrence	Bottleneck (specify)	Rank	Time and Cost to Correct
Rough Grinding			
Fine Grinding			
Polishing			
Hand Correction			
Coating			
Assembly			
Testing			
Materials			
Parts/Components			
Govt. Regulations			

2. MOBILIZATION BOTTLENECKS: List and rank the bottlenecks you envision would be encountered in a mobilization and the time and cost to correct. Rank bottlenecks in order of occurrence. If the answer is "none", please indicate. Please refer to definition of bottleneck.

Area of Occurrence	Bottleneck (specify)	Rank	Time and Cost to Correct
Rough Grinding			
Fine Grinding			
Polishing			
Hand Correction			
Coating			
Assembly			
Testing			
Materials			
Parts/Components			
Govt. Regulations			

C. WORK FORCE

1. EMPLOYMENT: Enter the number of employees from 1981 through 1985 as requested below. (See definition of Scientists and Engineers, Production Workers, and Opticians)

	1981	1982	1983	1984	1985
Scientists and Engineers	____	____	____	____	____
Production Workers	____	____	____	____	____
Administration and Other	____	____	____	____	____
Total:					
How many Opticians are included above?	____	____	____	____	____

2. a. Enter work force shift information below. (See definition of production workers)

Operation	Average Number of Production Workers per Shift in 1985 1st	2nd	3rd	days/wk	Number of Production Workers/Shift if Operating at Practical Capacity 1st	2nd	3rd	days/wk
Rough Grinding	____	____	____	____	____	____	____	____
Fine Grinding	____	____	____	____	____	____	____	____
Polishing	____	____	____	____	____	____	____	____
Hand Correction	____	____	____	____	____	____	____	____
Coating	____	____	____	____	____	____	____	____
Assembly	____	____	____	____	____	____	____	____
Testing	____	____	____	____	____	____	____	____
Other	____	____	____	____	____	____	____	____

b. Assuming you were operating one eight hour shift, five days per week, how much additional production (expressed as a percent increase) could you acheive if:

You added a second eight hour shift? ______percent

You added a second and third eight hour shift? ______percent

c. Please use space below for any additional explanatory comments you have concerning the workforce shift information given in (2a. or b.) above (e.g., availiability of opticians or other occupations, union work rules, nighttime noise curfews, capital, etc.).

____

____

____

____

____

3. CRITICAL OCCUPATIONS: List below. (Critical Occupations - Includes occupations FOR WHICH YOU ANTICIPATE A POTENTIAL SHORTAGE OF QUALIFIED PERSONNEL DURING SURGE OR MOBILIZATION. In general, this would include skilled occupations that require an extended training period.)

Job Title	Number Employed	Number Needed in a Surge	Number Needed in a Mob.	Training Period (in months)

PART III - INVESTMENT, R&D, GOVERNMENT SPONSORED PROGRAMS, TECHNOLOGY, EQUIPMENT, SUPPLIERS, MATERIAL USAGE, AND TRANSPORTATION

INSTRUCTIONS

- Complete Part III for each establishment that manufactures precision optics.
- If information is not readily available from your records in exactly the form requested, furnish estimates and designate by the letter "E".
- Enter "none" where appropriate.
- Photocopy this section as necessary

ESTABLISHMENT IDENTIFICATION

______________ (Locality) ______________ (State) ______________ (Zip Code)

---

1. INVESTMENT: Enter expenditures for new plant, machinery, and equipment from 1981 through 1985 as requested below. Enter any government investment expenditures at your establishment separately.

Private Investment Expenditures
(in thousands of dollars)

	1981	1982	1983	1984	1985
Plant	____	____	____	____	____
Machinery and Equipment	____	____	____	____	____
Total:					

Government Funded Investment
(in thousands of dollars)

	1981	1982	1983	1984	1985
Plant	____	____	____	____	____
Machinery and Equipment	____	____	____	____	____
Total:					

2. Planned expansion: Enter percentage increase(+)/decrease(-) in practical production capacity planned for in the time frames indicated.

	Change in Capacity	Cost of Change	Description and Reason for Change
In one year	____	____	____________
In two-three years	____	____	____________
In over three years	____	____	____________

3. AGE OF CAPITAL EQUIPMENT: Enter the number of machines you have in each age interval on the table below.

Capital Equipment	Age Intervals 0-4 yrs	5-9 yrs	10-19 yrs	20yrs & up
Optical Sawing and Shaping Machines	____	____	____	____
Curve Generating Machines (Ring Tool)	____	____	____	____
Spindles (Lap Machines)	____	____	____	____
Centering and Edging Machines	____	____	____	____
Interferometers	____	____	____	____
Diamond Point Turning Machines	____	____	____	____
Vacuum Coating Chambers	____	____	____	____

4. RESEARCH AND DEVELOPMENT: Enter research and development expenditures from 1981 through 1985 as requested below. Enter any government funded expenditures separately. (See definition of research and development)

Private Funded Research and Development Expenditures
(in thousands of dollars)

	1981	1982	1983	1984	1985
On Materials	____	____	____	____	____
On Processes	____	____	____	____	____
Other	____	____	____	____	____
Total:					

Government Funded Research and Development Expenditures
(in thousands of dollars)

	1981	1982	1983	1984	1985
On Materials	____	____	____	____	____
On Processes	____	____	____	____	____
Other	____	____	____	____	____
Total:					

5. NEW TECHNOLOGIES: In which of the following areas do you consider the application of new technologies to be most critical? Number from one (the most critical) to seven (the least critical).

Grinding	________	Assembly	________
Polishing	________	Testing	________
Coating	________	Other (specify)	________
Calibration and Inspection	________		

List specific new technologies you would be most interested in acquiring.

____

____

6. GOVERNMENT SPONSORED PROGRAMS: (i.e. IMIP, TECH MOD, MANTECH, REPTECH - See definitions)

a. Are you currently involved in a Government sponsored modernization program with respect to your precision optics manufacturing operations? yes _____, no _____

b. How beneficial do you feel Government sponsored modernization programs are?

____

____

____

c. Will they result in reduced lead times? _____

Will they lower production costs? _____

Will they lower precision optics prices to DOD? _____

Will they help you compete on the world market? _____

d. What problems still exist that these programs do not address? ______________

____

____

____

____

7. PLANT INTEGRATION: For operations relating to the following items, what percent of your work did you subcontract out (rather than make yourself) in 1985?

Lenses	Flats	Reticles	Aspherics	Coatings
_______	_______	_______	_______	_______

Specify the manufacturing operations most frequently subcontracted.

____

____

For the periods indicated, estimate the percent changes in subcontracting you experienced or expect to experience.

	Lenses	Flats	Reticles	Aspherics	Coatings
From 1981 to 1985	_______	_______	_______	_______	_______
From 1986 to 1990	_______	_______	_______	_______	_______

8. INVENTORY: For the following materials, how much of an inventory do you normally maintain? (in days supply)

Optical Glass _____ Filter Glass _____ IR Material _____ Other (specify) _____

What factors influence your inventory policy for these materials (e.g., availability, tax policies, minimum purchase quantities, etc.)?

____

____

9. SUPPLIERS: Have you in the past five years experienced shortages or extended lead times in obtaining any material or supply, machinery, equipment, or additional labor that forced you to modify or curtail your operations?

Yes________, No________ If yes, list below. Identify the nature and duration of the problem on your operation and the action you took to resolve the situation.

____

____

10. Do you anticipate any shortages or extended lead times in obtaining any material or supply, machinery, equipment, or additional labor that could force you to modify or curtail your operations in the future?

Yes________, No________ If yes, please describe the nature and duration of the problem and the precautionary actions you can take to ease the impact on your operations.

____

____

11. For the following materials/machinery you used in the manufacture of precision optics in 1985, name and give the location (State or Foreign Country) of your top three sources of supply and the percentage of the total materials/machinery purchased from each.

	Optical Glass (Bulk & Pressings)		IR Material		Machinery	
a.	________	____%	________	____%	________	____%
b.	________	____%	________	____%	________	____%
c.	________	____%	________	____%	________	____%

12. Do you have any sole source or single source suppliers for manufacturing equipment, parts, components, or materials?

Yes________, No________ If yes, specify the equipment, part, component, or material, the name of the supplier, and how the loss of that supplier would effect your operations.

____

____

13. TRANSPORTATION: For the modes of transportation listed below used in shipping inbound and outbound parts or materials or finished precision optic elements or assemblies, please complete the following table.

Transport Mode	Please Check If Used	Frequency of Shipments	Typical Distances Shipped
Truck	______	________	______
Rail	______	________	______
Trailer or container on flat car	______	________	______
Air	______	________	______
Combination	______	________	______
Other (specify)	______	________	______

14. Are existing transportation services and networks in adequate supply and condition to accommodate a surge or mobilization? Yes__________, No__________If no, please explain why.

____

15. Are any critical parts or materials you use to make precision optics shipped from overseas? Yes__________, No__________If yes, please identify how shipped. (from foreign source to your plant)

____

____

PART IV - FOREIGN RELATIONSHIPS/FOREIGN SOURCING
(Part IV may be completed for your firm as a whole)

1. Enter the location and primary activity of any establishment outside the United States that your firm wholly or partly owns or controls or is affiliated with or has license agreements with, that manufactures precision optics.

Name	Country	Primary Activity

2. If any of the foreign establishments you listed above are integrated with your U.S. operations on a normal basis, please briefly specify the nature of that integration in the space provided below.

____

____

____

3. If the foreign establishments that you interact with suddenly ceased operations for an indefinite period, what adjustments would you need to make in your U.S. operations to counteract this interruption, how long would it take to establish a new source, and how would the interruption effect your surge and mobilization capabilities?

____

____

____

____

4. In recent years, have offset agreements affected your firm? (See definition of offset agreement)

__________yes __________no

If yes, how (cite examples)?______________________

____

____

____

____

5. For the following materials, indicate the percentage of imported material to the total material you use in the manufacture of precision optics.

Optical & Filter Glass ______ IR Material ______ Metal Mirror Substrate ______

Other (specify) ______

If material is imported, why (e.g., price, lead time, availability, quality)?

____

____

____

____

6. Complete the following table addressing which foreign made critical manufacturing equipment, parts, components, or supplies you use in your manufacturing operations. Use the following coded reasons why a foreign source is used in completing the table:

A. No known domestic source
B. Domestic source not available or inadequate
C. Offset agreement
D. Lower cost
E. Quicker delivery
F. Better quality
G. Other (specify)

Item	Country of Origin	For equipment Are spare parts/maintenance available only from a foreign source?	Reason why foreign source

PART V - INDUSTRIAL COMPETITIVENESS

(Part V may be completed for your firm as a whole)

1. On the table below, rank from one (the most competitive) to five (the least competitive) each competitive factor as it applies to firms producing precision optics in the United States, Japan, West Germany, Singapore and (other of your choice).

Competitive Factor	United States	Japan	West Germany	Singapore	Other (specify)
Price	____	____	____	____	____
Quality	____	____	____	____	____
Input costs:					
labor	____	____	____	____	____
capital	____	____	____	____	____
optical materials	____	____	____	____	____
other (specify)	____	____	____	____	____
Delivery (lead time)	____	____	____	____	____
Follow up service	____	____	____	____	____
Design capability	____	____	____	____	____
Engineering capability	____	____	____	____	____
Customer satisfaction	____	____	____	____	____
Trade barriers	____	____	____	____	____
Government supports	____	____	____	____	____

2. What, if anything, can the Government do to help mitigate the competitive disadvantages of U.S. firms you indicated above?

____

____

____

3. What cost reduction actions have you taken in recent years to increase your international competitiveness?

____

____

____

4. How do you view the competitive prospects for your firm's U.S. precision optics operations over the next five years?

They should:

improve greatly	____
improve somewhat	____
stay the same	____
decline somewhat	____
decline greatly	____

Please discuss the basis for your answer.____________________

____

____

____

5. Profitability: Enter the profitability of your U.S. precision optics operations for the years indicated.

	1981	1982	1983	1984	1985
Net Sales (1)	____	____	____	____	____
Cost of Goods Sold (2)	____	____	____	____	____
Gross Profit or (Loss) (3)	____	____	____	____	____
Net Income before Taxes (4)	____	____	____	____	____

(1) Including inter- and intracompany transfers
(2) Includes raw materials, direct labor and other factory costs such as depreciation and inventory carrying costs.
(3) Difference between Net Sales and Cost of Goods Sold
(4) Gross Profit or (Loss) less general, selling and administrative expenses, interest expenses and other expenses, plus other income

CERTIFICATION

The undersigned certifies that the information herein supplied in response to this questionnaire is complete and correct. The U.S. Code, Title 18 (Crimes and Criminal Procedure), Section 1001, makes it a criminal offense to willfully make a false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

(Date)	(Signature of Authorized Official)
(Area Code and Telephone Number)	(Type or Print Name and Title of Authorized Official)
(Area Code and Telephone Number)	(Type or Print Name and Title of Person to Contact Regarding this Report)

Comments: Please use the space below to provide any additional comments or information you may wish regarding your operations, or other related issues that impact your firm.

Form ITA-9056
(9-86)

U.S. Department of Commerce
International Trade Administration

OMB Approval Not Required: less than ten respondents

NATIONAL SECURITY ASSESSMENT OF OPTICAL MATERIALS INDUSTRY

THIS REPORT IS REQUIRED BY LAW

This report is required by law (50 U.S.C. App. Sec. 2155). Failure to report can result in a maximum fine of $1,000 or imprisonment up to one year, or both. Information furnished herewith is deemed confidential and will not be published or disclosed except in accordance with Section 705 of the Defense Production Act of 1950, as amended (50 U.S.C. App. Sec. 2155).

General Instructions

1. It is not our desire to impose an unreasonable burden on any respondent. IF INFORMATION IS NOT READILY AVAILABLE FROM YOUR RECORDS IN EXACTLY THE FORM REQUESTED, FURNISH ESTIMATES AND DESIGNATE BY THE LETTER "E". Any necessary comments or explanations should be supplied in the space provided or on separate sheets attached to this questionnaire. Ensure that you reference the proper question if you use extra sheets. If any answer is "none", please indicate.
2. Report calendar year data, unless otherwise specified in a particular question. Please complete Parts II and III separately for each of your establishments that produce optical materials in the United States. Please make photocopies of forms if additional copies are needed. For Parts I, IV and V, firms operating more than one establishment may combine the data for all establishments into a single report.
3. In addition to the original report form to be returned to us, a file copy is enclosed for your records. You are not legally required to fill out or retain this file copy. While it would be a convenience to the Government for a file copy to be made and retained for reference purposes, no assurances can be provided that file copies will be exempt from compulsory examination in the future.
4. Questions related to the questionnaire should be directed to Mr. Robert O'Shaughnessy, Physicist, (201) 724-6223, Department of the Army, Mr. Robert Spande, Physicist, (703) 664-6665, Department of the Army, or Mr. John Tucker, Industry Analyst, (202) 377-3795, Department of Commerce.
5. Before returning your completed questionnaire, be sure to sign the certification and identify the person and phone number to contact your firm.
6. Return completed questionnaire by October 26, 1986 to:

U.S. Department of Commerce
International Trade Administration
Office of Industrial Resource Administration
Attn: Brad Botwin, Program Manager for
Industrial Capabilities, Room H3876
Washington, D.C. 20230

DEFINITIONS

BOTTLENECK—During a production expansion, the production process, operation, procedure, material or labor requirement within your manufacturing establishment that would ultimately prevent or delay increased production.

CRITICAL OCCUPATIONS—Includes occupations for which you anticipate a potential shortage of qualified personnel during surge or mobilization. In general, this would include skilled occupations that require an extended training period.

ESTABLISHMENT—All facilities in which optical materials are produced. Includes auxiliary facilities operated in conjunction with (whether or not physically separate from) such production facilities. Does not include wholly owned distribution facilities.

FIRM—An individual proprietorship, partnership, joint venture, association, corporation (including any subsidiary corporation in which more than 50 percent of the outstanding voting stock is owned), business trust, cooperative, trustees in bankruptcy, or receivers under decree of any court, owning or controlling one or more establishments as defined above.

INDUSTRIAL MODERNIZATION INCENTIVE PROGRAM (IMIP)—IMIP is a joint venture between Government and industry to reduce weapon system acquisition cost through the implementation of modern manufacturing processes and increased or accelerated capital investments. IMIP is formalized through a contractual business agreement providing Government incentives for contractor capital investments.

MANUFACTURING TECHNOLOGY (MANTECH)—Any action which has as its objective, 1) the timely establishment or improvement of the manufacturing processes, techniques, or equipment required to support current and projected programs, and 2) the assurance of the ability to produce, reduce lead time, ensure economic availability of end items, reduce costs, increase efficiency, improve reliability, or to enhance safety and anti-pollution measures.

MOBILIZATION PRODUCTION CAPABILITY—The maximum realistic increase of sustainable optical material production a manufacturing establishment can achieve in the 12 month period following a declared national emergency. Report achievable increase in average monthly production at the end of 6 months, 12 months, and 24 months in Part II of the questionnaire. Non-Defense, non-optical material production limited to 25% of 1985 peacetime levels. Government financial assistance and prioritization of construction materials and outfitting equipment is available. Your existing manufacturing buildings may be enlarged, new buildings constructed or existing buildings currently used by you for non-manufacturing purposes may be converted into manufacturing facilities, and plant equipment acquired. Consider critical labor skills to operate at maximum sustained production levels. Target requirement is 4X your average monthly optical material production in 1985.

OFFSET AGREEMENTS—In international trade a range of industrial and commercial compensation practices when mandated, directly or indirectly, by a purchasing government or company as a condition of purchase. Offsets include co-production, licensed production, subcontractor production, overseas investment, technology transfer, and countertrade.

OPTICAL MATERIALS—Optical materials are materials that are ground, polished or molded from which precision optics are fabricated. These optics are used to transmit, refract or reflect light in the ultra-violet (0.1 to 4. micrometers), visible (0.4 to 0.7 micrometers), near infrared (0.7 to 3.0 micrometers) and/or infrared (3.0 to 16. micrometers) spectra.

PRACTICAL CAPACITY—Sometimes referred to as engineering or design capacity, this is the greatest level of output this plant can achieve within the framework of a realistic work pattern. In estimating practical capacity, please take into account the following considerations:

1. Under most circumstances assume your 1985 product mix. If no production took place in 1985 of a particular item or group of items which you have, or will have the capability to produce and can anticipate receiving orders for in the future, include a reasonable quantity as part of your 1985 product mix.
2. Consider only the machinery and equipment in place and ready to operate. Do not consider facilities which have been inoperative for a long period of time and, therefore, require extensive reconditioning before they can be made operative.
3. Take into account the additional downtime for maintenance, repair, or clean-up which would be required as you move from current operations to full capacity.
4. Do not consider overtime pay, added costs for materials, or other costs to be limiting factors in setting capacity.
5. Although it may be possible to expand plant output by using productive facilities outside of the plant, such as by contracting out subassembly work, do not assume the use of such outside facilities in greater proportion than has been characteristic of your operations.

PRODUCTION WORKERS—Persons, up through the line supervisor level, engaged in fabricating, processing, assembling, inspecting, receiving, storing, handling, packing, warehousing, or shipping. In addition, persons engaged in supporting activities such as maintenance, repair, product development, auxiliary production for your firm's own use, record keeping, and other services closely associated with production operations at your firm. Employees above the working supervisor level are excluded from this item.

REPAIR TECHNOLOGY (REPTECH)—Projects which improve DOD overhaul and repair operations.

RESEARCH AND DEVELOPMENT—Research and development includes basic and applied research in the sciences and in engineering, and design and development of prototype products and processes. For the purposes of this questionnaire, research and development includes activities carried on by persons trained, either formally or by experience, in the physical sciences including related engineering, if the purpose of such activity is to do one or more of the following things:

1. Pursue a planned search for new knowledge, whether or not the search has reference to a specific application.
2. Apply existing knowledge to problems involved in the creation of a new product or process, including work required to evaluate possible uses.
3. Apply existing knowledge to problems involved in the improvement of a present product or process.

SCIENTISTS AND ENGINEERS—Persons engaged in research and development work or production operations that have at least a four-year college education in the physical sciences or engineering.

SHIPMENTS—Report unit and dollar values of domestically produced optical materials shipped by your firm during the reporting period for each category for questions in Part 1. Such shipments should include inter-plant and intra-plant transfers, but should exclude shipments of products produced by other manufacturers for resale under your brand name. Do not adjust for returned shipments.

SINGLE SOURCE—An item currently being purchased from one source; other sources may be available, however, they may not be qualified or were not considered.

SURGE PRODUCTION CAPABILITY—The maximum sustainable level of optical material production that can be achieved within an existing establishment by the end of the 6 month period immediately following surge day while maintaining deliveries of all other materials at 1985 peacetime levels. Report achievable production quantities of optical material at the end of 3 months, and 6 months in Part II of the questionnaire. Procurement actions for additional materials to sustain surge production levels will be initiated on surge day. Existing idle equipment may be activated as is, repaired, or upgraded and brought into service, or used equipment may be purchased and installed if possible within the 6 month time frame. Labor may be hired and trained in numbers sufficient to operate around the clock and weekends allowing for necessary equipment maintenance and downtime. Target requirement is 2X your average monthly optical material production in 1985.

TECHNOLOGY MODERNIZATION (TECH MOD)—The coupling of modernization with the implementation of advanced manufacturing technology by providing incentives for contractor and subcontractor capitalization.

SOLE SOURCE—An item being purchased from one source, and no other production capability exists.

UNITED STATES—The term "United States" includes the fifty States, Puerto Rico, the District of Columbia, and the Virgin Islands.

PART I

FIRM IDENTIFICATION

1. Name and address of your firm or corporate division.

____

____

____

If your firm is wholly or partly owned by another firm, indicate the name and address of the parent firm and extent of ownership.

____

____

____

2. Identify the location of your optical materials manufacturing establishment(s) in the United States. (See definition of optical materials.)

	Locality	State	Zip Code
(a)			
(b)			
(c)			

3. Identify any U.S. manufacturing establishments in which you ceased optical materials production operations since 1980 and the reason production was stopped.

____

____

____

____

____

____

____

____

PART I - A. SHIPMENTS (POUNDS)

Enter total shipments of optical materials <u>in pounds except</u> preshaped blanks which shall be indicated by units.

	1981	1982	1983	1984	1985
1. Optical Blanks (Visible, near IR spectra), all glass types except for absorption filters.					
a. Preshaped Lens Blanks (size to fabricate lens): all grades.					
(1) Small (under .5" O.D.)	____	____	____	____	____
(2) Medium (.5 to 2" O.D.)	____	____	____	____	____
(3) Large (2 to 8" O.D.)	____	____	____	____	____
(4) Very Large (over 8" O.D.)	____	____	____	____	____
b. Strips					
(1) Grade A	____	____	____	____	____
(2) Grade B	____	____	____	____	____
(3) Grade C	____	____	____	____	____
(4) Grade D	____	____	____	____	____
(5) Other grades	____	____	____	____	____
c. Gobs					
(1) Grade A	____	____	____	____	____
(2) Grade B	____	____	____	____	____
(3) Grade C	____	____	____	____	____
(4) Grade D	____	____	____	____	____
(5) Other grades	____	____	____	____	____
d. Slabs					
(1) Grade A	____	____	____	____	____
(2) Grade B	____	____	____	____	____
(3) Grade C	____	____	____	____	____

	1981	1982	1983	1984	1985
(4) Grade D	____	____	____	____	____
(5) Other grades	____	____	____	____	____
e. Sheets					
(1) Grade A	____	____	____	____	____
(2) Grade B	____	____	____	____	____
(3) Grade C	____	____	____	____	____
(4) Grade D	____	____	____	____	____
(5) Other grades	____	____	____	____	____
2. Zinc Selenide, Zinc Sulfide, Germanium, Silicon Optical Grade IR Materials					
a. Lenses, preshaped blank (size to fabricate lens)					
(1) Small (under 1" O.D.)	____	____	____	____	____
(2) Medium (1" to 2.5" O.D.)	____	____	____	____	____
(3) Large (2.5" to 6" O.D.)	____	____	____	____	____
(4) Very Large (6" to 12" O.D.)	____	____	____	____	____
b. Windows (when non-circular use smallest O.D. dimension)					
(1) Small (under 1" O.D., under 0.080" thick)	____	____	____	____	____
(2) Medium (1" to 2.5" O.D., under 0.200" thick)	____	____	____	____	____
(3) Large (2.5" to 6" O.D., under 0.500" thick)	____	____	____	____	____
(4) Very Large (6" to 12" O.D. under 1.50" thick)	____	____	____	____	____
c. Prisms (blanks sized to fabricate 2 prisms)					
(1) Small (under .5 sq. in. face)	____	____	____	____	____
(2) Medium (.5 to 1 sq. in. face)	____	____	____	____	____

	1981	1982	1983	1984	1985
(3) Large (1 to 2 sq. in. face)	____	____	____	____	____
(4) Very Large (over 2 sq. in. face)	____	____	____	____	____

3. Ultraviolet (specify material in space at bottom of page)

a. Blanks (sized to fabricate windows - when non-circular use smallest O.D. dimension, lenses)

	1981	1982	1983	1984	1985
(1) Small (under .5" O.D.)	____	____	____	____	____
(2) Medium (.5" to 1" O.D.)	____	____	____	____	____
(3) Large (1" to 3" O.D.)	____	____	____	____	____
(4) Very large (over 3" O.D.)	____	____	____	____	____

b. Prism Blanks (sized to fabricate 2 prisms)

	1981	1982	1983	1984	1985
(1) Small (under .5 sq. in. face)	____	____	____	____	____
(2) Medium (.5 to 1 sq. in. face)	____	____	____	____	____
(3) Large (1 to 2 sq. in. face)	____	____	____	____	____
(4) Very Large (over 2 sq. in. face)	____	____	____	____	____

PART I - B. SHIPMENTS (DOLLARS)

Enter total dollar shipments of optical materials.

	1981	1982	1983	1984	1985
1. Optical Blanks (Visible, near IR spectra), all glass types except for absorption filters.					
a. Preshaped Lens Blanks (size to fabricate lens): all grades.					
(1) Small (under .5" O.D.)	____	____	____	____	____
(2) Medium (.5 to 2" O.D.)	____	____	____	____	____
(3) Large (2 to 8" O.D.)	____	____	____	____	____
(4) Very Large (over 8" O.D.)	____	____	____	____	____
b. Strips					
(1) Grade A	____	____	____	____	____
(2) Grade B	____	____	____	____	____
(3) Grade C	____	____	____	____	____
(4) Grade D	____	____	____	____	____
(5) Other grades	____	____	____	____	____
c. Gobs					
(1) Grade A	____	____	____	____	____
(2) Grade B	____	____	____	____	____
(3) Grade C	____	____	____	____	____
(4) Grade D	____	____	____	____	____
(5) Other grades	____	____	____	____	____
d. Slabs					
(1) Grade A	____	____	____	____	____
(2) Grade B	____	____	____	____	____
(3) Grade C	____	____	____	____	____

	1981	1982	1983	1984	1985
(4) Grade D					
(5) Other grades					
e. Sheets					
(1) Grade A					
(2) Grade B					
(3) Grade C					
(4) Grade D					
(5) Other grades					
2. Zinc Selenide, Zinc Sulfide, Germanium, Silicon Optical Grade IR Materials					
a. Lenses, preshaped blank (size to fabricate lens)					
(1) Small (under 1" O.D.)					
(2) Medium (1" to 2.5" O.D.)					
(3) Large (2.5" to 6" O.D.)					
(4) Very Large (6" to 12" O.D.)					
b. Windows (when non-circular use smallest O.D. dimension)					
(1) Small (under 1" O.D., under 0.080" thick)					
(2) Medium (1" to 2.5" O.D., under 0.200" thick)					
(3) Large (2.5" to 6" O.D., under 0.500" thick)					
(4) Very Large (6" to 12" O.D. under 1.50" thick)					
c. Prisms (blanks sized to fabricate 2 prisms)					
(1) Small (under .5 sq. in. face)					
(2) Medium (.5 to 1 sq. in. face)					

	1981	1982	1983	1984	1985
(3) Large (1 to 2 sq. in. face)	____	____	____	____	____
(4) Very Large (over 2 sq. in. face)	____	____	____	____	____

3. Ultraviolet (specify materials in space at bottom of page)

a. Blanks (sized to fabricate windows - when non-circular use smallest O.D. dimension, lenses)

	1981	1982	1983	1984	1985
(1) Small (under .5" O.D.)	____	____	____	____	____
(2) Medium (.5" to 1" O.D.)	____	____	____	____	____
(3) Large (1" to 3" O.D.)	____	____	____	____	____
(4) Very large (over 3" O.D.)	____	____	____	____	____

b. Prism Blanks (sized to fabricate 2 prisms)

	1981	1982	1983	1984	1985
(1) Small (under .5 sq. in. face)	____	____	____	____	____
(2) Medium (.5 to 1 sq. in. face)	____	____	____	____	____
(3) Large (1 to 2 sq. in. face)	____	____	____	____	____
(4) Very Large (over 2 sq. in. face)	____	____	____	____	____

PART II - A. PEACETIME CAPACITY
B. SURGE AND MOBILIZATION PRODUCTION CAPABILITY

INSTRUCTIONS

- o Complete Part II for each establishment that manufactures optical materials.
- o Report calendar year data, unless otherwise specified.
- o If information is not readily available from your records in exactly the form requested, furnish estimates and designate by the letter "E".
- o Do not leave questions unanswered. Enter "none" where appropriate.
- o Photocopy this section as necessary.

ESTABLISHMENT IDENTIFICATION

____________	____________	____________
(Locality)	(State)	(Zip Code)

A. PEACETIME CAPACITY

What is your annual practical capacity for producing optical materials in the following size and spectral ranges? Enter practical capacity in pounds of optical materials except preshaped blanks which shall be indicated by units. (See definition of practical capacity.)

1. Optical Blanks (Visible, near IR Spectra). All glass types except for absorption filters.

a. Preshaped Lens Blanks (size to fabricate lens): all grades

(1) Small (under .5" O.D. ____

(2) Medium (.5 to 2" O.D.) ____

(3) Large (2 to 8" O.D.) ____

(4) Very Large (over 8" O.D.) ____

b. Strips

(1) Grade A ____

(2) Grade B ____

(3) Grade C ____

(4) Grade D ____

(5) Other Grades ____

c. Gobs

(1) Grade A ____

(2) Grade B ____

(3) Grade C ____

(4) Grade D ____

(5) Other grades ____

d. Slabs

(1) Grade A ____

(2) Grade B ____

(3) Grade C ____

(4) Grade D ____

(5) Other grades ____

e. Sheets

(1) Grade A wt. in lbs ____

(2) Grade B wt. in lbs ____

(3) Grade C wt. in lbs ____

(4) Grade D wt. in lbs ____

(5) Other grades ____

2. Zinc Selenide, Zinc Sulfide, Germanium, Silicon Optical Grade IR Materials.

a. Lenses, preshaped blank (size to fabricate lens)

(1) Small (under 1" O.D.) ____

(2) Medium (1" to 2.5" O.D.) ____

(3) Large (2.5" to 6" O.D.) ____

(4) Very Large (6" to 12" O.D.) ____

b. Windows (when non-circular use smallest O.D. dimension)

(1) Small (under 1" O.D., under 0.080" thick) ____

(2) Medium (1" to 2.5" O.D., under 0.200" thick) ____

(3) Large (2.5" to 6" O.D., under 0.500" thick) ____

(4) Very Large (6" to 12" O.D., under 1.50" thick) ____

c. Prisms (blanks sized to fabricate 2 prisms)

(1) Small (under .5 sq. in. face) ____

(2) Medium (.5 to 1 sq. in. face) ____

(3) Large (1 to 2 sq. in. face) ____

(4) Very Large (over 2 sq. in. face) ____

3. Ultraviolet (specify material)

a. Blanks (sized to fabricate windows - when non-circular use smallest O.D. dimension, lenses)

(1) Small (under .5" O.D.) ____

(2) Medium (.5" to 1" O.D.) ____

(3) Large (1" to 3" O.D.) ____

(4) Very large (over 3" O.D.) ____

b. Prism Blanks (sized to fabricate 2 prisms)

(1) Small (under .5 sq. in. face ____

(2) Medium (.5 to 1 sq. in. face) ____

(3) Large (1 to 2 sq. in. face) ____

(4) Very Large (over 2 sq. in. face) ____

4. Enter below factors which would increase/decrease capacity figures given above. (e.g. material, length of production run, etc.)

____

____

____

5. a. What was this establishment's practical capacity utilization rate in percent in 1985?

   Practical Capacity Utilization: ____% 1985

   b. How long would it take to reach practical capacity from the 1985 rate indicated? (in weeks)

   ____ Weeks

6. LEAD TIMES:

   a. During 1985, what was your average lead time (i.e., from receipt of order to delivery to customer)?

   ____ Weeks

   b. Regarding your longest lead time items, list the type of materials, the average lead time during 1985, and describe how that lead time could be significantly shortened.

Type of Material (specify)	1985 Average Lead Time	How to Shorten Lead Time

   c. Are lead times increasing? Yes ____, No ____ If yes, what are the reasons?

____

____

____

____

____

B. SURGE AND MOBILIZATION PRODUCTION CAPABILITY

Enter your optical material surge and mobilization production capabilities below? Use 1985's average monthly production of optical material for each category shown on the table as your base production rate. Enter production rates in pounds of optical materials except preshaped blanks which shall be indicated by units. (See definition of surge and mobilization production capability.)

	Base Rate	Surge Rate at 3 mo.s	Surge Rate at 6 mo.s	Mob Rate at 6 mo.s	Mob Rate at 12 mo.s	Mob Rate at 24 mo.s
1. Optical Blanks (Visible, near IR Spectra) (All glass types except for absorption filters)						
a. Preshaped Lens Blanks (size to fabricate lens): all grades.						
(1) Small (under .5" O.D.)	____	____	____	____	____	____
(2) Medium (.5 to 2" O.D.)	____	____	____	____	____	____
(3) Large (2 to 8" O.D.)	____	____	____	____	____	____
(4) Very Large (over 8" O.D.)	____	____	____	____	____	____
b. Strips						
(1) Grade A	____	____	____	____	____	____
(2) Grade B	____	____	____	____	____	____
(3) Grade C	____	____	____	____	____	____
(4) Grade D	____	____	____	____	____	____
(5) Other grades	____	____	____	____	____	____
c. Gobs						
(1) Grade A	____	____	____	____	____	____
(2) Grade B	____	____	____	____	____	____
(3) Grade C	____	____	____	____	____	____
(4) Grade D	____	____	____	____	____	____
(5) Other grades	____	____	____	____	____	____

	Base Rate	Surge Rate at 3 mo.s	at 6 mo.s	Mob Rate at 6 mo.s	at 12 mo.s	at 24 mo.s
d. Slabs						
(1) Grade A	____	____	____	____	____	____
(2) Grade B	____	____	____	____	____	____
(3) Grade C	____	____	____	____	____	____
(4) Grade D	____	____	____	____	____	____
(5) Other grades	____	____	____	____	____	____
e. Sheets						
(1) Grade A	____	____	____	____	____	____
(2) Grade B	____	____	____	____	____	____
(3) Grade C	____	____	____	____	____	____
(4) Grade D	____	____	____	____	____	____
(5) Other grades	____	____	____	____	____	____
2. Zinc Selenide, Zinc Sulfide, Germanium, Silicon Optical Grade IR Materials						
a. Lenses, preshaped blank (size to fabricate lens)						
(1) Small (under 1" O.D.)	____	____	____	____	____	____
(2) Medium (1" to 2.5" O.D.)	____	____	____	____	____	____
(3) Large (2.5" to 6" O.D.)	____	____	____	____	____	____
(4) Very Large (6" to 12" O.D.)	____	____	____	____	____	____
b. Windows (when non-circular use smallest O.D. dimension)						
(1) Small (under 1" O.D., under 0.080" thick)	____	____	____	____	____	____
(2) Medium (1" to 2.5" O.D., under 0.200" thick)	____	____	____	____	____	____
(3) Large (2.5" to 6" O.D., under 0.500" thick)	____	____	____	____	____	____

	Base Rate	Surge Rate at 3 mo.s	Surge Rate at 6 mo.s	Mob Rate at 6 mo.s	Mob Rate at 12 mo.s	Mob Rate at 24 mo.s
(4) Very Large (6" to 12" O.D. under 1.50" thick)	____	____	____	____	____	____
c. Prisms (blanks sized to fabricate 2 prisms)						
(1) Small (under .5 sq. in. face)	____	____	____	____	____	____
(3) Large (1 to 2 sq. in. face)	____	____	____	____	____	____
(2) Medium (.5 to 1 sq. in. face)	____	____	____	____	____	____
(4) Very Large (over 2 sq. in. face)	____	____	____	____	____	____
3. Ultraviolet (specify material)						
a. Blanks (sized to fabricate windows - when non-circular use smallest O.D. dimension, lenses)						
(1) Small (under .5" O.D.)	____	____	____	____	____	____
(2) Medium (.5" to 1" O.D.)	____	____	____	____	____	____
(3) Large (1" to 3" O.D.)	____	____	____	____	____	____
(4) Very large (over 3" O.D.)	____	____	____	____	____	____
b. Prism Blanks (sized to fabricate 2 prisms)						
(1) Small (under .5 sq. in. face)	____	____	____	____	____	____
(2) Medium (.5 to 1 sq. in. face)	____	____	____	____	____	____
(3) Large (1 to 2 sq. in. face)	____	____	____	____	____	____
(4) Very Large (over 2 sq. in. face)	____	____	____	____	____	____

4. List and rank the bottlenecks you envision would be encountered in a surge and the time and cost to correct. Rank bottlenecks in order of occurrence. If the answer is "none", please indicate. Refer to definition of bottleneck.

Area of Occurrence	Bottleneck (specify)	Rank	Time and Cost to Correct
Raw Materials Handling	______	___	______
Crystal Growing	______	___	______
Processing	______	___	______
Inspection	______	___	______
Testing	______	___	______
Support other than Clerical or Administrative	______	___	______

5. List and rank the bottlenecks you envision would be encountered in a mobilization and the time and cost to correct. Rank bottlenecks in order of occurrence. If the answer is "none", please indicate. Please refer to definition of bottleneck.

Area of Occurrence	Bottleneck (specify)	Rank	Time and Cost to Correct
Raw Materials Handling	______	___	______
Crystal Growing	______	___	______
Processing	______	___	______
Inspection	______	___	______
Testing	______	___	______
Support other than Clerical or Administrative	______	___	______

6. What can the Government and/or your firm do to help reduce or eliminate bottlenecks?

____

____

____

____

PART III - INVESTMENT, EQUIPMENT, R&D, TECHNOLOGY, EMPLOYMENT, SUPPLIERS, MATERIAL USAGE, TRANSPORTATION, AND GOVERNMENT SPONSORED PROGRAMS

INSTRUCTIONS

- o Complete Part III for each establishment that manufactures optical materials.
- o If information is not readily available from your records in exactly the form requested, furnish estimates and designate by the letter "E".
- o Enter "none" where appropriate.

ESTABLISHMENT IDENTIFICATION

(Locality)	(State)	(Zip Code)

1. INVESTMENT: Enter expenditures for new plant, machinery, and equipment from 1981 through 1985 as requested below. Enter any government investment expenditures at your establishment separately.

Private Investment Expenditures
(in thousands of dollars)

	1981	1982	1983	1984	1985
Plant	____	____	____	____	____
Machinery and Equipment	____	____	____	____	____
Total:					

Government Funded Investment
(in thousands of dollars)

	1981	1982	1983	1984	1985
Plant	____	____	____	____	____
Machinery and Equipment	____	____	____	____	____
Total:					

2. Planned expansion: Enter percentage increase(+)/decrease(-) in practical production capacity planned for in the time frames indicated.

	Change in Capacity	Cost of Change	Description and Reason for Change
In one year	____	____	____
In two-three years	____	____	____
In over three years	____	____	____

3. AGE OF CAPITAL EQUIPMENT: Enter the number of machines you have in each age interval on the table below.

	Age Intervals			
Capital Equipment	0-4 yrs	5-9 yrs	10-19 yrs	20 yrs & up
Furnaces	____	____	____	____
Annealing Ovens	____	____	____	____
Vacuum Chambers	____	____	____	____
Other (specify)	____	____	____	____

4. RESEARCH AND DEVELOPMENT: Enter research and development expenditures from 1981 through 1985 as requested below. Enter any government funded expenditures separately. (See definition of research and development.)

Private Funded Research and Development Expenditures
(in thousands of dollars)

	1981	1982	1983	1984	1985
On Materials	____	____	____	____	____
On Processes	____	____	____	____	____
Other	____	____	____	____	____
Total:					

Government Funded Research and Development Expenditures
(in thousands of dollars)

	1981	1982	1983	1984	1985
On Materials	____	____	____	____	____
On Processes	____	____	____	____	____
Other	____	____	____	____	____
Total:					

5. NEW TECHNOLOGIES: List specific new technologies for increasing production of optical materials you would be most interested in acquiring.

____

____

6. EMPLOYMENT: Enter the number of employees from 1981 through 1985 as requested below. (See definition of Scientists and Engineers, and Production Workers)

	1981	1982	1983	1984	1985
Scientists and Engineers	____	____	____	____	____
Production Workers	____	____	____	____	____
Administration and Other	____	____	____	____	____
Total:					

7. a. Enter work force shift information below. (See definition of production workers)

	Average Number of Production Workers per Shift in 1985				Number of Production Workers/Shift if Operating at Practical Capacity			
Operation	1st	2nd	3rd	days/wk	1st	2nd	3rd	days/wk
Raw Materials Handling	____	____	____	____	____	____	____	____
Crystal Growing	____	____	____	____	____	____	____	____
Processing	____	____	____	____	____	____	____	____
Inspection	____	____	____	____	____	____	____	____
Testing	____	____	____	____	____	____	____	____
Support other than Clerical or Administrative	____	____	____	____	____	____	____	____

b. Assuming you were operating one eight hour shift five days per week, how much additional production (expressed as a percent increase) could you acheive if:

You added a second eight hour shift? ______ percent

You added a second and third eight hour shift? ______ percent

c. Please use space below for any additional explanatory comments you have regarding the work force shift information given in (7a. or b.) above.

____

____

____

____

8. CRITICAL OCCUPATIONS: List below. (See definition of critical occupations)

Job Title	Number Employed	Number Needed in a Surge	Training Period (in months)
____________	______	______	______
____________	______	______	______
____________	______	______	______
____________	______	______	______

9. INVENTORY: For the following materials, how much of an inventory do you normal maintain? (in days supply)

Germanium Concentrate _____ Zinc Metal _____ Hydrogen Selenide _____

Hydrogen Sulfide _____ Silicon Starting Materials _____ Other (Specify) _____

What factors influence your inventory policy for these materials (e.g., availability, tax policies, minimum purchase quantities, etc.)?

____

____

____

10. SUPPLIERS: For the following materials/machinery you used in the manufacture of optical materials in 1985, name and give the location (state or foreign country) of your top five sources of supply and the percentage of the total materials/machinery purchased from each.

	Materials		Machinery	
a.	____________	_____%	____________	_____%
b.	____________	_____%	____________	_____%
c.	____________	_____%	____________	_____%
d.	____________	_____%	____________	_____%
e.	____________	_____%	____________	_____%

11. Have you in the past five years experienced shortages or extended leadtimes in obtaining any material or supply, machinery, equipment, or additional labor that forced you to modify or curtail your operations?

Yes________, No________ If yes, list below. Identify the nature and duration of the problem on your operation and the action you took to resolve the situation.

____

____

12. Do you anticipate any shortages or extended leadtimes in obtaining any material or supply, machinery, equipment, or additional labor that could force you to modify or curtail your operations in the future?

Yes________, No________ If yes, please describe the nature and duration of the problem and the precautionary actions you can take to ease the impact on your operations.

____

13. Do you have any sole source or single source suppliers for manufacturing equipment, parts, components, or materials?

Yes________, No________ If yes, specify the equipment, part, component, or material, the name of the supplier, and how the loss of that supplier would effect your operations.

____

____

____

14. TRANSPORTATION: For the modes of transportation listed below used in shipping inbound and outbound materials or parts, please complete the following table.

Transport Mode	Please Check If Used	Frequency of Shipments	Typical Distances Shipped
Truck	________	____________	________
Rail	________	____________	________
Trailer or container on flat car	________	____________	________
Air	________	____________	________
Combination	________	____________	________
Other (specify)	________	____________	________

15. Are existing transportation services and networks in adequate supply and condition to accomodate a surge or mobilization?

Yes__________, No__________ If no, please explain why ______________________________

____

16. Are any critical parts or materials you use to make optical materials shipped from overseas?

Yes__________, No__________If yes, please identify how shipped. (from foreign source to

your plant)____

17. GOVERNMENT SPONSORED PROGRAMS: (i.e. IMIP, TECH MOD, MANTECH, REPTECH - See definitions)

a. Are you currently involved in a Government sponsored modernization program with respect to your optical material manufacturing operations? yes _____, no _____

b. How beneficial do you feel Government sponsored modernization programs are?

____

____

____

c. Which programs could help your firm? ______________________________

____

d. Will they result in reduced lead times? _____

Will they lower production costs? _____

Will they lower optical material prices? _____

Will they help you compete on the world market? _____

e. What problems still exist that these programs do not address? ____________

____

____

____

____

PART IV - FOREIGN RELATIONSHIPS/FOREIGN SOURCING
(Part IV may be completed for your firm as a whole)

1. Enter the location and primary activity of any establishment outside the United States that your firm wholly or partly owns or controls or is affiliated with or has license agreements with, that manufactures optical materials, or supplies raw materials from which optical materials are manufactured.

Name	Country	Primary Activity

2. If any of the foreign establishments you listed above are integrated with your U.S. operations on a normal basis, please briefly specify the nature of that integration in the space provided below.

____

____

____

3. If the foreign establishments that you interact with suddenly ceased operations for an indefinite period, what adjustments would you need to make in your U.S. operations to counteract this interruption, how long would it take to establish a new source, and how would the interruption effect your surge and mobilization capabilities?

____

____

____

____

4. In recent years, have offset agreements affected your firm? (See definition of offset agreement)

__________ Yes, __________ No

If yes, how (cite examples)? ______________________________

____

____

____

____

5. Indicate the percentage of imported material to the total material you use in the manufacture of optical materials by type.

Metals ______ Concentrates ______ Gases ______ Catalysts ______

If material is imported, why (e.g., price, lead time, availability, quality)?

______

______

______

______

6. Complete the following table addressing which foreign made critical manufacturing equipment, parts, components, or supplies you use in your manufacturing operations. Use the following coded reasons why a foreign source is used in completing the table:

A. No known domestic source
B. Domestic source not available or inadequate
C. Offset agreement
D. Lower cost
E. Quicker delivery
F. Better quality
G. Other (specify)

Item	Country of Origin	For equipment Are spare parts/maintenance available only from a foreign source?	Reason why foreign source

PART V - INDUSTRIAL COMPETITIVENESS

1. On the table below, rank from one (the most competitive) to five (the least competitive) each competitive factor as it applies to firms producing optical materials in the United States, Canada, Austria, Belgium, and other (specify).

Competitive Factor	United States	Canada	Austria	Belgium	Other (specify)
Price	____	____	____	____	____
Quality	____	____	____	____	____
Input costs:					
labor	____	____	____	____	____
capital	____	____	____	____	____
other (specify)	____	____	____	____	____
Delivery (lead-time)	____	____	____	____	____
Follow up service	____	____	____	____	____
Research capability	____	____	____	____	____
Customer statisfaction	____	____	____	____	____
Trade barriers	____	____	____	____	____
Government supports	____	____	____	____	____

2. What, if anything, can the Government do to help mitigate the competitive disadvantages of U.S. firms you indicated above?

____

____

____

3. What cost reduction actions have you taken in recent years to increase your international competitiveness?

____

____

____

____

4. How do you view the competitive prospects for your firm's U.S. optical materials operations over the next five years?

They should:
- improve greatly ______
- improve somewhat ______
- stay the same ______
- decline somewhat ______
- decline greatly ______

Please discuss the basis for your answer.______________________________

____

____

____

5. Profitability: Enter the profitability of your U.S. optical material operations for the years indicated.

	1981	1982	1983	1984	1985
Net Sales (1)	____	____	____	____	____
Cost of Goods Sold (2)	____	____	____	____	____
Gross Profit or (Loss) (3)	____	____	____	____	____
Net Income Before Taxes (4)	____	____	____	____	____

(1) Including inter- and intracompany transfers
(2) Includes raw materials, direct labor and other factory costs such as depreciation and inventory carrying costs
(3) Difference between Net Sales and Cost of Goods Sold
(4) Gross Profit or (Loss) less general, selling and administrative expenses, interest expenses and other expenses, plus other income

CERTIFICATION

The undersigned certifies that the information herein supplied in response to this questionnaire is complete and correct. The U.S. Code, Title 18 (Crimes and Criminal Procedure), Section 1001, makes it a criminal offense to willfully make a false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

______________________ (Date)	______________________ (Signature of Authorized Official)
______________________ (Area Code and Telephone Number)	______________________ (Type or Print Name and Title of Authorized Official)
______________________ (Area Code and Telephone Number)	______________________ (Type or Print Name and Title of Person to Contact Regarding this Report)

Comments: Please use the space below to provide any additional comments or information you may wish regarding your operations, or other related issues that impact your firm.

APPENDIX C

'84 Proposed FAR Clause

ORIGINAL PROPOSED '84 CLAUSE

Insert for Part 8 of the DoD FAR Supplement

Part 8 - Required Sources of Supplies and Services

Subpart 8.77 - Precision Optics Items used for direct military application including military binoculars

8.7701 - Definitions.

"Precision optics items" means lenses either in prototype or production quantities that must meet specified tolerances and dimensions with optical wavefront errors across most of the useful field of view which do not exceed one micrometer in magnitude.

"Domestic manufacture" means precision optics items manufactured in the United States and Canada/

"End-item" means a final combination of end products, component parts, and/or materials which is ready for its intended use per JCS Publication #1 (DoD Dictionary of Military and Associated Terms).

8.7702 - Policy

It has been determined that defense requirements for Precision Optics Items must be acquired from domestic sources (U.S. and Canada) to the maximum extent practical. Accordingly, all acquisitions of precision optics items including preforms/blanks, and components (smaller than 12 inches in diameter) and all acquisitions of items containing precision optics items shall include, except as provided in 8.7702 below, a requirement that such items and precision optics items incorporated in end items delivered under the contract be of domestic manufacture only. This restriction does not include medical or personal optics items such as microscopes, reading glasses, and commercial binoculars.

8.7703 - Procedures

(a) The clause set forth at 52.208-7004, Required Sources of Precision Optics Items, shall be inserted in all contracts except:

(1) when the contracting officer knows that the item being acquired does not contain precision optics items;

(2) when purchases are made overseas for overseas use;

(b) Subsequent to the award of a contract, the contracting officer may waive the requirements set forth at 52.208-7004, Required Sources for Precision Optics Items. Such waiver may be granted on a case-by-case basis when adequate domestic supplies of precision optics items are not available to meet DoD needs on a timely basis. Also, these waivers will only be granted to the extent and for the period of time necessary to permit the contractor to acquire and use precision optics items of domestic manufacture.

ORIGINAL PROPOSED '84 CLAUSE

Insert for Part 52 of DoD FAR Supplement

Subpart 52.208-7004, Required Sources for Precision Optics Items used for direct military application including military binoculars, as prescribed at 8.7703, insert the following clause:

Required Sources for Precision Optics Items (May 1984)

(a) For the purpose of this clause:

"Precision optics items" means lenses either in prototype or production quantities that must meet specified tolerances and dimensions with optical wavefront errors across most of the useful field of view which do not exceed one micrometer in magnitude.

"Domestic manufacture" means precision optics items manufactured in the United States or Canada.

"End-item" means a final combination of end products, component parts, and/or materials which is ready for its intended use, per JCS Publication #1 (DoD Dictionary of Military and Associated Terms).

(b) The contractor agrees that end items, components, and processed materials thereof delivered under this contract shall contain domestic precision optic items including preforms/blanks, and components (smaller than 12 inches in diameter) of U.S. or Canadian manufacture only. This restriction does not include medical or personal optics items such as microscopes, reading glasses, and commercial binoculars.

(c) The contractor agrees to insert this clause, including this paragraph (c), in every subcontract and purchase order issued in performance of this contract, unless he knows that the item being purchased contains no precision optics items.

(d) The contractor agrees to retain until the expiration of three years from the date of final payment under this contract and to make available during such period, upon request of the contracting officer, records showing compliance with this clause.

(e) The requirement for delivery in (b) above may be waived in whole or in part on a case-by-case basis by the contracting officer when such a waiver is determined to be in the government's interest and it meets the provisions of subpart 8.77.

Note: These cost estimates, particularly for the more distant future, should be viewed with care as they apply only to the weapon systems shown. Orders for some of these systems will be completed during the forcast period, which may give the false impression that forcasted defense spending for optical components is on a declining trend. Omitted from the calculation are new weapon systems that will undoubtably go into production, but for which information was not available.

APPENDIX D

JPOTG Proposed FAR Clause

RECOMMENDED REVISED FAR CLAUSE
(with Attachment A-1)

Insert for Part 8 of the DOD FAR Supplement

Part 8 - Required Sources of Supplies and Services.

Subpart 8.77 - Precision Optical Elements used for direct military applications including military binoculars.

8.7701 - Definitions:

"Precision Optics" means elements made by grinding, polishing, turning, or molding material to be used to transmit, refract, or reflect light in the visual (.4 to .7 micrometers), near infrared (.7 to 3.0 micrometers), and/or infrared (3.0 to 16.0 micrometers) spectra. This includes elements in systems which are type-classified or purchased as Non-Developmental Items (NDI).

"Precision Optical Elements" includes, but is not limited to lenses, prisms, mirrors, reticles, beamsplitters, windows, filters, laser rods, and pressings/preforms/blanks/optical glass for the foregoing.

"Optical Glass" is material which meets specification MIL-G-174 and is used for visual and/or infrared precision optical elements.

"Domestic manufacture" means Precision Optical Elements manufactured in the United States and Canada.

"End-item" means a final combination of end products, component parts, and/or materials which is ready for its intended use.

"Components" mean those articles, materials, elements, and supplies directly incorporated into end products.

Excluded are: infrared blanks/pressings/preforms (such as germanium, zinc sulfide, zinc selenide), filter glass blanks/pressings/preforms, prescription eyeglasses, molded plastics, fiber optics, windshields and canopies, medical instruments, microscope components, faceplates for tubes, gratings, coverplates for indicators, vehicle head-lamps, and traffic reflectors.

8.7702 - Policy

DOD has determined that defense requirements for Precision Optics Elements must be acquired from domestic sources (United States and Canada) to the maximum extent practical. Defense requirements must be acquired in such a way as to assure domestic production capability. To ensure a domestic production capability for precision optical elements is available, DOD has determined that a seven (7) year FAR restriction be implemented. For procurements signed before October 1, 1989, a minimum of 50% of the quantity of each optical element must be of domestic manufacture. Between October 1, 1989 and September 30, 1994, 100% of the quantity of each optical element must be of domestic manufacture.

Based upon the production surge and mobilization objectives established by the cognizant DOD component, the provisions of FAR 6.202 and 6.302-3 will be used to ensure that domestic capability exists to produce all parts of a weapon system and that the production process for all parts and final weapon system production/assembly can be accomplished by domestic producers.

Accordingly, all acquisition of precision optical elements including pressings/preforms/blanks of optical glass and all acquisitions of end items containing precision optical elements shall include, except as provided in 8.7703 below, a requirement that such precision optical elements in end items delivered under the contract be of domestic manufacture only.

8.7703 - Procedures:

The clause set forth at 52.208-7004, Required Sources of Precision Optics Elements, shall be inserted in all contracts except:

a. when the contracting officer knows that the item being acquired does not contain precision optics items;

b. when purchases are made overseas for overseas use;

c. when the contracting officer determines that domestic sources are incapable of or unavailable to provide such elements. The contracting officer shall request from the Command level a waiver of the provisions of part 52.208-7004 and shall provide in writing justification for each action. The waiver granted by the proper level of authority shall only be for the period of time necessary to permit the contractor to acquire and use domestic production sources; that procurements made under this determination are subject to periodic audit by the Defense Contract Audit Agency to avoid possible excessive cost to DOD;

Implementation of this restrictive clause shall be determined on a contract by contract basis at the Procuring Contracting Office (PCO) level. Prior to award of a contract for items containing optical elements as defined in 8.7701 above, the PCO shall ensure that 50% of each optical element be purchased from domestic sources for the first two years of implementation of this restriction. For the five following years, the PCO shall make sure that 100% of optical elements are purchased from domestic sources.

ATTACHMENT A-1

Insert for Part 52 of DOD FAR Supplement

Subpart 52.208-7004, Required Sources for Precision Optics Items used for direct military application including binoculars, as prescribed at 8.7702, insert the following clause:

Required Sources for Precision Optics Elements

a. For the purpose of this clause:

"Precision Optics" means elements made by grinding, polishing, turning, or molding material to be used to transmit, refract, or reflect light in the visual (.4 to .7 micrometers), near infrared (.7 to 3.0 micrometers), and/or infrared (3.0 to 16.0 micrometers) spectra. This includes elements in systems which are type-classified or purchased as Non-Developmental Items (NDI).

"Precision Optical Elements" includes, but is not limited to lenses, prisms, mirrors, reticles, beamsplitters, windows, filters, laser rods, and pressings/preforms/blanks/optical glass for the foregoing.

"Optical Glass" is material which meets specification MIL-G-174 and is used for visual and/or infrared precision optical elements.

"Domestic manufacture" means Precision Optical Elements manufactured in the United States and Canada.

"End-item" means a final combination of end products, component parts, and/or materials which is ready for its intended use.

"Components" mean those articles, materials, elements, and supplies directly incorporated into end products.

Excluded are: infrared blanks/pressings/preforms (such as germanium, zinc sulfide, zinc selenide), filter glass blanks/pressings/preforms, prescription eyeglasses, molded plastics, fiber optics, windshields and canopies, medical instruments, microscope components, faceplates for tubes, gratings, coverplates for indicators, vehicle head-lamps, and traffic reflectors.

b. The contractor agrees that end items, components, and processed materials thereof delivered under this contract shall contain domestic precision optics items including preforms/blanks/pressings/optical glass, and components of U.S. or Canadian manufacture only. This restriction does not include those items excluded in a. above.

c. The contractor agrees to insert this clause, including this paragraph (c), in every subcontract and purchase order issued in performance of this contract, unless he knows that the item being purchased contains no precision optics items.

b. The contractor agrees to retain all receipts until the expiration of three years from the date of final payment under this contract and to make available during such period, upon request of the contracting officer, records showing compliance with this clause.

c. The requirement for delivery in (b) above may be waived in whole or in part on a case-by-case basis by the contracting officer when such a waiver is determined to be in the Government's interest and it meets the provision of subpart 8.7703. The contracting officer must first receive major command level approval.

APPENDIX E

Optical Elements: U.S. Trade Statistics, 1978-1986

OPTICAL ELEMENTS: U.S. TRADE STATISTICS, 1978-1986

TABLES

FIGURES

TABLE 1

U.S. IMPORTS AND EXPORTS, 1978-1986
OPTICAL ELEMENTS INCLUDING ELEMENTS CONTAINED IN END-PRODUCTS:

BY QUANTITY

TOTAL IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	116,280,480	124,302,493	128,641,770	144,814,088	148,206,523	156,435,785	223,167,418	280,785,822	279,182,091
JAPAN	85,844,985	84,265,152	100,926,859	108,495,014	111,756,847	116,573,653	155,410,850	154,818,867	140,573,426
TAIWAN	6,639,060	6,629,870	4,834,072	5,022,992	6,928,401	8,919,774	22,735,633	46,025,504	82,627,073
KOREA	5,786,497	5,185,330	5,065,216	7,098,596	8,401,365	9,428,450	16,188,975	22,453,523	22,799,801
SINGAPORE	527,380	988,950	463,673	1,407,610	753,840	775,588	695,855	679,252	881,111
EC	3,336,740	4,188,893	4,721,274	6,256,779	5,649,446	8,153,269	7,682,483	7,941,013	12,233,313
UK	280,833	487,918	675,336	472,373	681,959	1,886,685	2,294,306	3,085,000	6,725,328
W.GERMANY	2,556,907	3,074,247	3,632,209	4,678,524	3,171,487	2,376,705	2,293,094	2,191,694	2,268,200
ALL OTHERS	14,165,807	13,644,098	12,630,678	16,533,097	14,716,623	12,585,051	20,453,643	48,067,664	40,067,367

TOTAL EXPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	31,800,271	41,528,942	36,616,337	34,775,097	48,003,305	31,560,163	27,116,278	36,639,599	35,611,100
JAPAN	2,354,683	3,105,432	2,979,746	2,585,042	5,376,703	3,381,693	3,140,541	2,785,752	2,211,007
TAIWAN	445,212	91,695	140,787	391,052	179,011	355,353	137,607	373,963	226,985
KOREA	394,665	495,180	124,373	299,092	275,553	1,028,217	492,030	1,040,543	417,988
SINGAPORE	196,577	223,130	277,580	589,413	1,315,329	622,185	1,153,227	83,798	79,083
EC	11,689,980	15,607,685	13,556,516	13,713,529	18,149,773	12,564,788	9,706,402	12,931,003	16,462,256
UK	2,742,493	3,250,649	7,653,819	4,998,340	6,836,122	9,245,929	3,014,791	4,605,081	4,978,948
W.GERMANY	2,746,449	2,454,103	4,148,980	5,022,488	4,734,547	3,436,895	1,045,395	514,487	257,464
ALL OTHERS	16,719,155	22,005,819	19,537,354	17,196,976	22,706,936	13,607,928	12,488,471	19,444,540	16,213,781

Source: Department of Commerce

TABLE 2

U.S. IMPORTS AND EXPORTS, 1978–1986
OPTICAL ELEMENTS INCLUDING ELEMENTS CONTAINED IN END-PRODUCTS:

BY VALUE

TOTAL IMPORTS: DOLLAR VALUE

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	167,356,577	231,650,757	283,558,348	313,071,399	371,125,502	404,863,382	601,587,890	691,844,427	991,856,103
JAPAN	117,807,167	118,600,795	150,960,993	168,521,165	130,381,901	170,838,259	254,957,731	324,503,719	309,190,927
TAIWAN	1,142,984	8,536,671	5,820,224	8,295,012	26,337,337	16,216,422	42,987,876	200,242,907	296,332,929
KOREA	2,690,083	5,885,915	8,901,642	7,905,825	49,338,854	18,306,782	142,613,180	239,080,089	107,905,016
SINGAPORE	3,468,843	22,907,789	6,851,848	5,397,536	5,411,661	10,174,762	13,647,361	15,080,924	21,090,418
EC	20,908,315	39,825,436	38,311,408	44,428,135	101,574,213	47,686,533	38,026,744	35,751,194	77,530,729
UK	5,163,890	8,017,972	1,445,582	1,860,116	5,113,507	1,972,257	5,813,575	5,181,745	19,423,997
W.GERMANY	14,928,006	26,626,945	55,711,300	46,015,075	76,438,812	28,186,780	14,331,065	33,960,402	45,265,282
ALL OTHERS	11,423,139	28,230,470	17,072,435	21,859,483	20,785,746	33,209,734	109,355,218	42,898,282	156,984,360

TOTAL EXPORTS: DOLLAR VALUE

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	91,537,026	154,787,096	161,422,965	150,359,521	240,411,156	163,358,460	148,193,801	180,504,660	252,981,589
JAPAN	6,769,714	10,160,973	13,136,209	11,177,203	26,927,602	17,503,979	16,931,912	13,625,475	15,706,996
TAIWAN	1,279,983	300,027	620,571	1,690,829	898,520	1,839,343	741,894	1,842,328	1,612,501
KOREA	1,134,661	1,620,229	548,300	1,293,212	1,380,027	5,322,151	2,652,729	5,128,237	2,969,383
SINGAPORE	565,160	730,083	1,223,713	2,548,506	6,587,430	3,220,490	6,217,509	412,832	581,808
EC	33,608,692	51,068,348	59,763,902	59,294,529	90,897,694	65,036,600	52,331,098	63,704,585	116,847,864
UK	7,884,868	10,636,124	33,741,881	21,611,823	34,236,667	47,857,854	16,253,944	22,686,933	35,370,447
W.GERMANY	7,896,041	8,029,824	18,290,780	21,716,233	23,711,557	17,789,712	5,636,143	2,534,520	1,829,024
ALL OTHERS	48,178,815	90,907,437	86,130,271	74,355,241	113,721,882	70,435,897	67,318,459	95,783,203	115,183,036

Source: Department of Commerce

TABLE 3

U.S. IMPORTS, 1978-1986
OPTICAL ELEMENTS INCLUDING ELEMENTS CONTAINED IN END-PRODUCTS:

PERCENTAGE MARKET SHARES BY COUNTRY

TOTAL IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
JAPAN	73.83%	75.84%	78.46%	74.92%	75.41%	74.52%	69.84%	55.07%	50.35%
TAIWAN	5.71%	5.33%	3.76%	3.47%	4.67%	5.70%	10.19%	16.39%	22.43%
KOREA	4.86%	4.17%	3.94%	4.90%	5.67%	6.03%	7.25%	8.00%	8.17%
SINGAPORE	0.45%	0.31%	0.36%	0.97%	0.51%	0.50%	0.31%	0.24%	0.32%
EC	2.87%	3.37%	3.67%	4.32%	3.81%	5.21%	3.44%	2.83%	4.38%
UK	0.25%	0.39%	0.52%	0.33%	0.46%	1.21%	1.03%	1.10%	2.41%
W.GERMANY	2.20%	2.47%	2.82%	3.23%	2.14%	1.52%	1.03%	0.78%	0.81%
ALL OTHERS	12.18%	10.98%	9.82%	11.42%	9.93%	8.04%	9.17%	17.48%	14.35%

TOTAL IMPORTS: DOLLAR VALUE

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
JAPAN	70.27%	51.20%	53.24%	53.83%	35.13%	42.20%	42.38%	48.82%	31.18%
TAIWAN	0.68%	3.69%	2.05%	2.65%	7.10%	4.01%	7.15%	28.95%	29.88%
KOREA	1.81%	2.54%	3.14%	2.53%	13.28%	4.52%	23.71%	34.57%	10.88%
SINGAPORE	2.07%	9.89%	2.42%	1.72%	1.46%	2.51%	2.27%	2.16%	2.13%
EC	12.49%	17.19%	13.51%	14.19%	27.37%	11.78%	8.32%	5.17%	7.82%
UK	3.09%	3.46%	0.51%	0.53%	1.38%	0.49%	0.87%	0.75%	1.96%
W.GERMANY	8.92%	11.49%	19.65%	14.70%	20.60%	6.96%	2.38%	4.91%	4.56%
ALL OTHERS	6.83%	12.19%	6.02%	6.92%	5.60%	8.20%	18.18%	6.20%	15.83%

Source: Department of Commerce

TABLE 4

TOTAL U.S. IMPORTS OF OPTICAL ELEMENTS 1978–1986

BY END-PRODUCT: ELEMENTS

End Product	1978	1979	1980	1981	1982	1983	1984	1985	1986
TOTAL	116,280,480	124,302,493	128,641,770	144,814,088	148,206,523	156,435,785	223,167,418	280,785,822	279,182,091
Still cameras	21,830,356	24,060,516	22,448,802	28,760,484	30,055,398	34,796,532	57,948,608	101,151,612	122,259,150
Telescopes	19,079,900	19,620,430	21,685,190	21,059,750	23,981,860	25,356,690	30,112,180	57,169,670	42,900,410
Photographic Lenses, Mounted	22,391,922	31,733,502	32,368,482	36,976,098	41,144,988	38,306,160	55,935,684	38,211,222	38,517,156
Binoculars	20,360,800	14,290,400	16,495,270	22,538,710	21,653,150	26,725,530	37,722,470	39,531,170	34,029,910
Optical Elements, Unmounted	12,228,672	12,938,255	10,504,116	11,330,116	13,215,197	10,820,057	13,856,940	14,064,942	13,171,427
Optical Elements, Mounted	6,795,216	8,937,000	10,044,174	10,729,728	7,675,074	7,367,436	10,219,830	12,622,884	10,773,042
Photocopiers	NA	NA	2,603,784	3,537,560	3,268,672	4,473,720	5,898,024	7,203,296	8,648,456
Projection Lenses, Mounted	7,142,502	7,368,534	7,295,328	6,219,018	4,421,550	5,006,970	5,951,874	6,023,460	4,672,062
Microscopes	745,768	289,646	563,766	938,056	927,220	1,312,486	1,280,380	1,616,720	2,022,188
Projectors	1,795,104	2,974,362	2,713,746	1,305,888	1,149,198	1,476,612	2,047,208	1,837,398	1,849,730
Motion Cameras	3,910,240	2,089,848	1,919,112	1,418,680	714,216	783,592	2,184,224	1,353,448	538,560

BY END-PRODUCT: PERCENTAGE SHARE OF TOTAL

End Product	1978	1979	1980	1981	1982	1983	1984	1985	1986
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Still cameras	18.8%	19.4%	17.5%	19.9%	20.3%	22.2%	26.0%	36.0%	43.8%
Telescopes	16.4%	15.8%	16.9%	14.5%	16.2%	16.2%	13.5%	20.4%	15.4%
Photographic Lenses, Mounted	19.3%	25.5%	25.2%	25.5%	27.8%	24.5%	25.1%	13.6%	13.8%
Binoculars	17.5%	11.5%	12.8%	15.6%	14.6%	17.1%	16.9%	14.1%	12.2%
Optical Elements, Unmounted	10.5%	10.4%	8.2%	7.8%	8.9%	6.9%	6.2%	5.0%	4.7%
Optical Elements, Mounted	5.8%	7.2%	7.8%	7.4%	5.2%	4.7%	4.6%	4.5%	3.9%
Photocopiers	NA	NA	2.0%	2.4%	2.2%	2.9%	2.6%	2.6%	3.1%
Projection Lenses, Mounted	6.1%	5.9%	5.7%	4.3%	3.0%	3.2%	2.7%	2.1%	1.7%
Microscopes	0.6%	0.2%	0.4%	0.6%	0.6%	0.8%	0.6%	0.6%	0.7%
Projectors	1.5%	2.4%	2.1%	0.9%	0.8%	0.9%	0.9%	0.7%	0.6%
Motion Cameras	3.4%	1.7%	1.5%	1.0%	0.5%	0.5%	1.0%	0.5%	0.2%

Source: Department of Commerce

TABLE 5

STILL CAMERAS
CONTAINED ELEMENTS

U. S. IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	21,830,358	24,060,516	22,448,802	28,760,484	30,055,398	34,798,532	57,948,608	101,151,612	122,259,150
JAPAN	17,341,056	18,629,708	19,567,362	22,314,966	20,951,052	28,139,588	31,958,930	35,467,644	42,267,480
TAIWAN	1,100,772	1,620,156	1,231,044	2,248,746	3,581,804	4,945,428	14,214,600	37,687,788	50,581,092
KOREA	32,580	43,848	56,256	30,654	123,396	111,156	1,367,496	2,119,842	2,842,932
SINGAPORE	380,762	271,638	215,748	396,450	5,970	13,152	84,146	35,178	7,452
EC	574,494	596,370	216,534	714,390	718,332	1,127,172	1,674,510	2,782,190	6,541,200
UK	136,764	321,954	87,396	41,286	308,582	723,696	1,236,978	1,844,460	5,016,150
W.GERMANY	400,320	198,564	89,394	601,314	344,064	265,848	295,928	562,808	779,154
ALL OTHERS	2,380,694	2,898,798	1,161,858	3,055,278	4,694,844	2,460,036	8,637,924	23,078,970	20,018,994

U. S. EXPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	20,818,158	23,910,804	22,819,044	23,954,544	34,919,466	16,748,874	13,928,658	15,887,316	19,674,138
JAPAN	1,927,122	2,390,076	1,697,796	1,668,438	4,237,488	1,682,298	574,404	372,498	373,704
TAIWAN	366,300	12,660	65,838	20,670	29,160	7,620	64,716	83,858	102,012
KOREA	13,658	24,858	1,170	4,506	12,498	10,356	36,078	5,664	4,188
SINGAPORE	157,128	189,756	142,356	103,602	555,414	87,834	38,352	7,128	6,228
EC	7,815,798	9,680,118	7,907,940	8,995,920	12,621,846	6,625,080	5,382,318	7,461,420	11,321,526
UK	1,954,508	2,325,192	1,757,130	1,391,790	3,620,682	3,214,512	1,172,370	1,309,158	699,906
W.GERMANY	2,004,930	1,598,274	1,997,946	3,417,318	3,186,084	1,428,510	458,340	93,102	59,766
ALL OTHERS	10,505,526	11,660,736	13,140,072	12,709,596	17,930,640	8,385,168	7,864,014	7,957,848	7,886,480

Source: Department of Commerce

TABLE 6

TELESCOPES
CONTAINED ELEMENTS

U. S. IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	19,079,900	19,620,430	21,685,190	21,059,750	23,981,860	25,356,690	30,112,180	57,169,670	42,900,410
JAPAN	14,875,990	13,858,720	17,100,720	15,094,640	14,300,500	16,006,770	17,896,890	27,161,440	17,441,390
TAIWAN	39,360	90,840	2,240	204,520	111,140	90,040	270,970	2,362,660	5,869,670
KOREA	1,111,820	1,589,710	1,225,250	3,025,880	4,270,260	4,841,760	7,332,350	15,283,570	11,626,720
SINGAPORE	0	7,300	0	0	18,090	0	0	11,250	134,450
EC	56,530	335,380	447,470	621,770	579,810	157,030	325,010	86,740	1,051,950
UK	6,060	15,030	9,720	7,230	17,430	27,670	7,420	15,360	917,520
W.GERMANY	30,680	293,470	435,850	482,770	560,350	126,900	97,900	76,100	71,550
ALL OTHERS	2,996,200	3,738,480	2,909,510	2,112,940	4,702,060	4,261,090	4,286,960	12,254,010	6,776,230

U. S. EXPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	3,400,245	7,944,028	4,748,955	2,448,425	2,785,772	4,422,154	4,903,992	10,956,592	7,544,665
JAPAN	21,403	65,561	55,777	53,984	62,236	87,174	37,958	148,975	133,904
TAIWAN	13,966	37,244	40,640	298,999	66,257	236,355	0	162,069	15,286
KOREA	297,029	419,943	56,272	209,344	19,837	824,562	416,897	918,735	219,905
SINGAPORE	150	1,460	0	152,000	2,741	198,611	529,722	4,219	1,023
EC	19,855	1,118,839	910,264	650,144	489,249	149,113	116,339	40,107	756,122
UK	1,802	81,817	4,160	6,003	14,463	44,440	3,295	5,035	3,498
W.GERMANY	4,553	108,199	979,921	581,373	299,989	89,472	21,189	17,794	20,000
ALL OTHERS	3,047,841	6,300,981	3,684,001	1,081,953	2,145,452	2,926,339	3,803,078	9,682,487	6,418,426

Source: Department of Commerce

TABLE 7

PHOTOGRAPHIC LENSES, Mounted
CONTAINED ELEMENTS

U. S. IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	22,391,922	31,733,502	32,368,482	36,976,098	41,144,988	38,308,160	55,935,684	38,211,222	38,517,156
JAPAN	19,530,714	28,304,496	28,538,796	31,447,866	34,891,770	31,726,884	47,677,248	33,539,412	30,107,562
TAIWAN	1,705,802	1,809,036	1,527,306	1,896,942	2,032,830	1,606,770	2,172,972	1,240,350	1,249,446
KOREA	438,720	665,970	1,170,450	2,112,630	2,281,236	2,837,118	4,803,606	2,593,752	5,087,586
SINGAPORE	8,160	6,546	7,332	4,080	3,210	38,126	36	1,200	1,356
EC	537,054	678,444	867,054	863,280	1,572,084	1,811,790	960,528	515,790	922,398
UK	5,928	9,150	4,890	2,286	19,770	33,504	31,986	11,844	4,818
W.GERMANY	516,180	653,460	851,634	453,264	261,842	558,858	241,998	150,348	118,344
ALL OTHERS	171,672	269,010	257,544	651,300	363,858	287,472	321,294	320,718	1,148,808

U. S. EXPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	578,948	735,444	501,222	596,322	712,530	840,726	624,864	1,648,016	164,790
JAPAN	17,406	12,618	16,794	24,792	72,966	27,882	46,126	46,956	34,260
TAIWAN	330	1,008	138	1,440	270	732	156	0	834
KOREA	300	408	4,680	19,752	46,122	83,754	216	5,934	2,460
SINGAPORE	480	150	12	1,182	426	5,562	798	5,748	30
EC	261,594	415,500	259,212	402,564	500,862	578,478	401,106	1,546,826	54,492
UK	71,454	216,986	89,358	322,242	453,906	553,746	376,212	1,449,762	8,178
W.GERMANY	13,512	151,782	129,390	44,454	24,258	14,250	11,778	38,328	16,684
ALL OTHERS	298,836	305,760	220,386	146,592	91,884	144,318	174,462	48,452	72,714

Source: Department of Commerce

TABLE 8

BINOCULARS
CONTAINED ELEMENTS

U. S. IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	20,360,800	14,290,400	16,495,270	22,538,710	21,653,150	28,725,530	37,722,470	39,531,170	34,029,810
JAPAN	10,340,790	6,910,640	9,187,110	13,512,250	16,405,950	17,809,020	25,825,830	26,158,420	18,677,740
TAIWAN	3,148,700	2,794,080	1,599,760	6,000	446,560	1,085,770	2,806,550	2,888,980	3,008,990
KOREA	4,024,290	2,661,260	2,071,480	1,685,940	1,539,130	1,443,550	2,471,360	2,336,150	2,273,800
SINGAPORE	0	0	0	0	0	0	0	7,800	0
EC	208,310	190,710	152,760	162,940	196,770	2,313,700	1,567,230	1,595,850	876,060
UK	6,070	20,350	160	450	2,100	80	7,980	1,330	400
W.GERMANY	164,810	126,020	121,250	99,680	130,810	213,550	280,510	306,820	253,950
ALL OTHERS	2,638,710	1,733,710	3,484,180	7,171,580	3,084,740	4,073,490	5,251,500	6,743,970	9,193,320

U. S. EXPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	434,220	1,019,720	848,700	498,540	660,570	1,213,360	709,510	841,990	1,191,530
JAPAN	16,020	19,930	20,650	64,230	27,310	54,960	77,050	88,090	132,750
TAIWAN	5,410	2,280	10,390	3,610	8,130	43,460	12,790	73,210	6,970
KOREA	54,630	18,210	32,760	26,770	35,390	8,380	14,690	66,660	81,070
SINGAPORE	900	3,280	2,850	2,990	3,790	13,800	15,480	12,800	10,530
EC	171,570	248,330	340,970	157,210	327,580	391,300	325,110	123,970	341,030
UK	17,080	30,970	21,130	24,790	18,970	16,650	75,020	11,170	102,940
W. GERMANY	40,380	53,880	55,810	23,330	13,300	110,650	136,900	54,340	58,540
ALL OTHERS	185,690	727,690	441,080	243,730	258,390	701,460	264,390	477,860	639,180

Source: Department of Commerce

TABLE 9

OPTICAL ELEMENTS, Unmounted
CONTAINED ELEMENTS

U. S. IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	12,228,672	12,838,255	10,504,116	11,330,116	13,215,197	10,820,057	13,858,940	14,064,842	13,171,427
JAPAN	7,973,869	10,898,364	7,806,695	7,535,300	10,414,839	7,414,811	10,597,758	8,850,299	8,654,296
TAIWAN	540,194	94,058	290,912	309,998	226,481	481,922	657,917	344,418	540,681
KOREA	139,383	169,184	67,154	167,008	125,325	146,792	105,571	93,077	880,425
SINGAPORE	13,862	8,912	91,613	699,856	399,966	322,108	324,421	211,298	285,815
EC	857,144	798,775	990,472	1,050,033	825,506	1,663,617	1,680,125	1,432,241	1,331,805
UK	33,173	29,554	483,316	275,505	250,103	1,046,547	848,848	1,111,052	702,014
W.GERMANY	442,043	422,445	336,073	543,540	384,825	473,653	821,276	197,604	217,588
ALL OTHERS	2,904,219	968,964	1,257,272	1,567,921	1,223,079	790,807	491,151	3,333,612	1,478,405

U. S. EXPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	3,345,518	4,323,226	2,991,705	2,719,297	4,282,048	2,184,043	1,683,935	1,835,861	1,680,882
JAPAN	251,121	319,121	244,598	204,068	477,500	235,419	193,761	137,711	102,786
TAIWAN	48,084	10,503	11,770	31,127	16,958	24,991	8,848	19,576	11,147
KOREA	45,278	55,661	10,819	24,776	26,584	75,252	32,366	54,653	19,907
SINGAPORE	22,504	25,333	19,817	25,141	60,471	27,048	40,758	3,045	2,647
EC	1,103,698	1,467,735	953,078	968,132	1,517,781	743,523	502,127	559,004	726,728
UK	285,653	354,834	193,616	176,720	423,967	306,092	125,752	155,410	47,789
W.GERMANY	267,072	245,972	334,876	376,577	407,419	204,593	50,464	24,688	12,482
ALL OTHERS	1,874,832	2,444,873	1,751,522	1,466,052	2,182,754	1,077,811	906,076	1,061,671	817,666

Source: Department of Commerce

TABLE 10

OPTICAL ELEMENTS, Mounted
CONTAINED ELEMENTS

U. S. IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	6,795,216	8,837,000	10,044,174	10,729,728	7,675,074	7,367,436	10,219,830	12,622,884	10,773,042
JAPAN	5,686,098	7,071,798	7,424,712	7,737,300	5,925,966	6,428,256	8,790,246	9,620,352	9,171,408
TAIWAN	0	125,802	22,488	110,112	38,244	24,462	112,584	92,604	201,780
KOREA	1,620	50,688	469,224	74,154	57,696	43,464	100,998	16,350	41,970
SINGAPORE	75,558	11,538	32,490	167,796	295,644	262,848	267,450	409,518	444,708
EC	619,356	1,209,126	1,530,792	2,343,678	1,268,028	417,402	580,898	618,834	526,296
UK	68,802	61,194	54,654	50,472	13,440	10,874	60,270	29,442	21,144
W.GERMANY	406,830	1,118,022	1,432,074	2,265,012	1,250,538	364,392	448,038	574,184	467,820
ALL OTHERS	412,584	488,048	564,468	286,888	89,496	191,004	367,654	1,885,228	386,880

U. S. EXPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	354,927	543,688	544,103	709,976	724,220	644,753	527,415	1,028,172	753,882
JAPAN	38,579	104,945	107,459	195,954	183,789	138,985	186,672	198,879	120,859
TAIWAN	8,000	13,320	6,276	25,242	11,510	25,296	28,983	39,028	71,850
KOREA	506	1,701	5,083	3,198	8,480	6,123	4,040	7,536	65,464
SINGAPORE	11,725	1,618	212	4,790	6,489	13,853	2,868	2,537	17,276
EC	35,101	72,052	106,017	222,837	130,947	52,660	49,299	92,400	50,016
UK	19,384	8,124	7,406	5,427	3,940	7,474	11,614	1,896	5,011
W.GERMANY	11,327	43,588	66,356	167,609	40,709	15,812	26,221	86,320	13,138
ALL OTHERS	261,017	350,051	319,057	257,954	403,005	407,836	257,555	684,794	428,418

Source: Department of Commerce

TABLE 11

PHOTOCOPIERS
CONTAINED ELEMENTS

U. S. IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	NA	NA	2,603,784	3,537,560	3,268,672	4,473,720	5,898,024	7,203,296	8,648,456
JAPAN	NA	NA	2,396,144	3,364,200	3,103,328	4,248,872	5,489,248	6,756,736	8,165,000
TAIWAN	NA	NA	3,136	1,544	1,664	96	240	80	200
KOREA	NA	NA	800	2,296	3,272	2,608	1,352	5,192	1,328
SINGAPORE	NA	NA	0	0	32	624	0	0	128
EC	NA	NA	160,000	118,592	127,800	161,304	264,352	214,112	253,344
UK	NA	NA	160	336	896	13,168	30,632	2,144	7,376
W.GERMANY	NA	NA	129,040	64,672	69,032	78,056	41,072	5,304	10,168
ALL OTHERS	NA	NA	43,704	50,928	32,576	60,216	132,832	227,176	228,456

U. S. EXPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	NA	NA	NA	311,792	339,720	348,304	343,120	274,424	404,128
JAPAN	NA	NA	NA	13,176	13,040	15,128	12,176	16,592	22,712
TAIWAN	NA	NA	NA	1,192	688	368	640	344	608
KOREA	NA	NA	NA	448	208	1,120	1,888	544	80
SINGAPORE	NA	NA	NA	2,528	3,024	1,472	1,256	1,032	1,472
EC	NA	NA	NA	129,184	106,704	167,752	131,120	69,808	33,464
UK	NA	NA	NA	20,712	29,560	34,888	30,192	19,184	9,056
W.GERMANY	NA	NA	NA	17,320	14,800	31,112	28,240	17,832	1,048
ALL OTHERS	NA	NA	NA	165,264	216,056	162,464	196,040	186,104	345,792

Source: Department of Commerce

TABLE 12

PROJECTION LENSES, Mounted
CONTAINED ELEMENTS

U. S. IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	7,142,502	7,368,534	7,295,328	6,219,018	4,421,550	5,006,970	5,851,874	6,023,460	4,672,062
JAPAN	6,123,168	5,942,676	6,083,412	4,984,658	4,117,434	4,678,062	5,390,466	5,526,986	4,001,472
TAIWAN	0	0	9,000	0	0	0	7,878	852	369,114
KOREA	12,000	0	0	0	0	0	4,740	0	0
SINGAPORE	360	0	990	0	30,090	140,364	660	1,200	5,982
EC	254,328	221,834	185,154	180,702	135,300	137,448	206,070	191,238	204,882
UK	17,208	14,820	27,246	85,614	66,318	6,336	43,374	43,782	22,482
W.GERMANY	230,640	192,402	110,154	69,354	59,112	101,772	107,028	106,278	157,758
ALL OTHERS	752,646	1,203,924	1,016,772	1,043,658	138,726	51,098	342,080	303,174	90,612

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U. S. EXPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	230,862	487,446	1,481,946	720,270	1,484,964	3,368,544	2,839,866	2,747,748	3,199,314
JAPAN	18,180	30,840	749,418	313,422	204,480	1,110,654	1,928,282	1,710,624	1,210,074
TAIWAN	120	360	2,772	810	1,290	0	11,664	840	18,804
KOREA	1,200	264	0	240	3,354	2,550	5,700	17,526	36,450
SINGAPORE	210	396	30,906	8,628	3,732	5,928	3,822	8,190	1,350
EC	53,784	69,036	443,490	153,156	853,140	1,472,334	736,632	823,718	1,753,968
UK	11,628	23,604	21,120	43,446	28,938	17,544	10,572	16,032	17,094
W.GERMANY	18,024	16,440	395,520	67,644	501,996	951,768	0	0	0
ALL OTHERS	157,368	386,550	255,360	244,014	418,968	777,078	153,786	186,852	178,668

Source: Department of Commerce

TABLE 13

PROJECTORS
CONTAINED ELEMENTS

U. S. IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	1,795,104	2,974,362	2,713,746	1,305,888	1,149,198	1,476,612	2,047,206	1,837,398	1,649,730
JAPAN	689,238	597,366	697,464	397,986	540,150	818,658	699,438	579,894	357,078
TAIWAN	0	17,280	52,260	176,694	95,454	35,142	495,084	597,564	245,904
KOREA	6,000	3,444	2,100	6	0	1,824	0	4,176	13,200
SINGAPORE	38,688	83,016	115,500	139,176	216	366	8,454	1,410	120
EC	97,512	105,264	62,508	126,906	166,266	277,368	344,004	333,744	393,522
UK	15,066	8,052	3,024	4,758	576	5,250	3,690	9,888	25,368
W.GERMANY	38,184	25,074	24,846	34,014	65,082	137,574	91,134	77,976	76,536
ALL OTHERS	963,666	2,167,992	1,783,914	465,120	347,112	343,254	500,226	320,610	639,906

U. S. EXPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	2,166,942	1,969,050	1,710,234	1,707,498	1,239,396	1,059,384	940,422	811,188	731,496
JAPAN	76,254	85,404	81,822	66,138	89,718	47,034	49,956	28,862	39,600
TAIWAN	7,812	22,176	5,262	12,954	52,110	18,942	7,716	10,422	5,340
KOREA	11,718	10,692	16,656	10,302	9,804	9,372	4,812	5,328	5,280
SINGAPORE	7,902	9,012	18,732	17,688	18,018	16,932	13,782	11,088	11,016
EC	938,532	883,542	636,678	589,722	406,986	435,798	285,270	316,512	263,586
UK	312,936	294,888	206,172	193,452	133,224	188,334	100,452	120,096	105,810
W.GERMANY	164,724	132,180	129,180	109,692	72,954	78,768	63,906	59,922	43,188
ALL OTHERS	1,124,724	958,224	951,084	1,010,694	662,760	531,306	576,886	440,976	406,674

Source: Department of Commerce

TABLE 14

MICROSCOPES
CONTAINED ELEMENTS

U. S. IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	745,766	289,646	583,766	938,056	927,220	1,312,486	1,290,380	1,618,720	2,022,188
JAPAN	410,662	210,378	481,916	847,896	443,898	573,244	649,446	783,986	1,604,064
TAIWAN	112	0	14	700	380,072	612,528	483,526	70,728	204,036
KOREA	84	266	42	28	1,050	154	1,470	1,414	7,840
SINGAPORE	0	0	0	252	14	0	56	392	28
EC	324,100	48,438	91,602	55,216	50,862	64,806	89,600	158,354	110,152
UK	1,722	7,742	4,746	4,396	4,648	19,292	22,876	15,554	7,112
W.GERMANY	321,692	37,198	85,750	47,656	39,396	39,662	59,444	115,542	97,300
ALL OTHERS	10,808	32,584	10,192	33,984	51,324	61,754	86,282	601,848	96,068

U. S. EXPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	283,208	426,818	875,014	1,092,392	841,274	721,980	597,646	599,970	228,592
JAPAN	5,656	16,058	12,922	4,914	3,738	1,932	9,870	6,174	6,454
TAIWAN	6,552	1,162	980	1,974	3,724	3,332	8,960	1,568	3,220
KOREA	5,278	2,840	6,076	17,304	135,590	65,828	4,326	8,190	6,944
SINGAPORE	11,340	11,746	27,650	2,940	23,282	19,754	9,464	4,858	4,398
EC	50,274	77,266	104,580	106,582	57,456	125,552	152,614	122,052	71,022
UK	27,916	30,002	68,866	73,780	24,570	38,558	116,340	12,964	9,268
W.GERMANY	6,580	10,444	10,360	9,576	5,656	31,360	15,512	100,254	18,998
ALL OTHERS	209,496	317,828	721,812	956,928	617,876	499,954	418,804	455,476	136,556

Source: Department of Commerce

TABLE 15

MOTION CAMERAS
CONTAINED ELEMENTS

U. S. IMPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	3,910,240	2,089,848	1,919,112	1,418,680	714,216	793,592	2,184,224	1,353,448	538,560
JAPAN	2,873,400	1,841,008	1,662,528	1,247,952	661,960	729,488	424,352	373,888	125,836
TAIWAN	104,320	78,720	95,912	67,736	34,152	37,616	1,793,312	939,480	356,160
KOREA	0	960	2,480	0	0	24	32	0	24,000
SINGAPORE	0	0	0	0	608	0	632	8	1,072
EC	7,912	6,552	16,928	19,272	8,688	21,632	10,136	21,920	21,704
UK	40	72	24	40	96	168	152	144	844
W.GERMANY	5,528	5,592	16,144	17,248	8,336	16,440	8,768	18,752	16,032
ALL OTHERS	924,608	162,608	141,264	83,720	8,808	4,832	15,760	18,352	9,688

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U. S. EXPORTS: QUANTITY

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986
WORLD	188,480	169,328	99,248	16,568	15,082	9,190	17,077	12,857	38,482
JAPAN	15,344	20,968	6,624	455	872	549	1,910	369	571
TAIWAN	496	184		26	20	49	0	27	102
KOREA	808	8	29	190	180	183	174	113	6
SINGAPORE	1,576	600	18	12	537	40	28	131	110
EC	41,224	68,864	3,356	4,756	2,949	2,965	3,842	2,457	24,832
UK	12,976	42,180	888	1,484	775	1,054	3,178	1,180	3,920
W.GERMANY	7,608	2,088	610	671	315	255	77	191	18,599
ALL OTHERS	128,032	80,704	89,222	11,129	10,524	5,424	11,123	9,760	12,861

Source: Department of Commerce

FIGURE 1

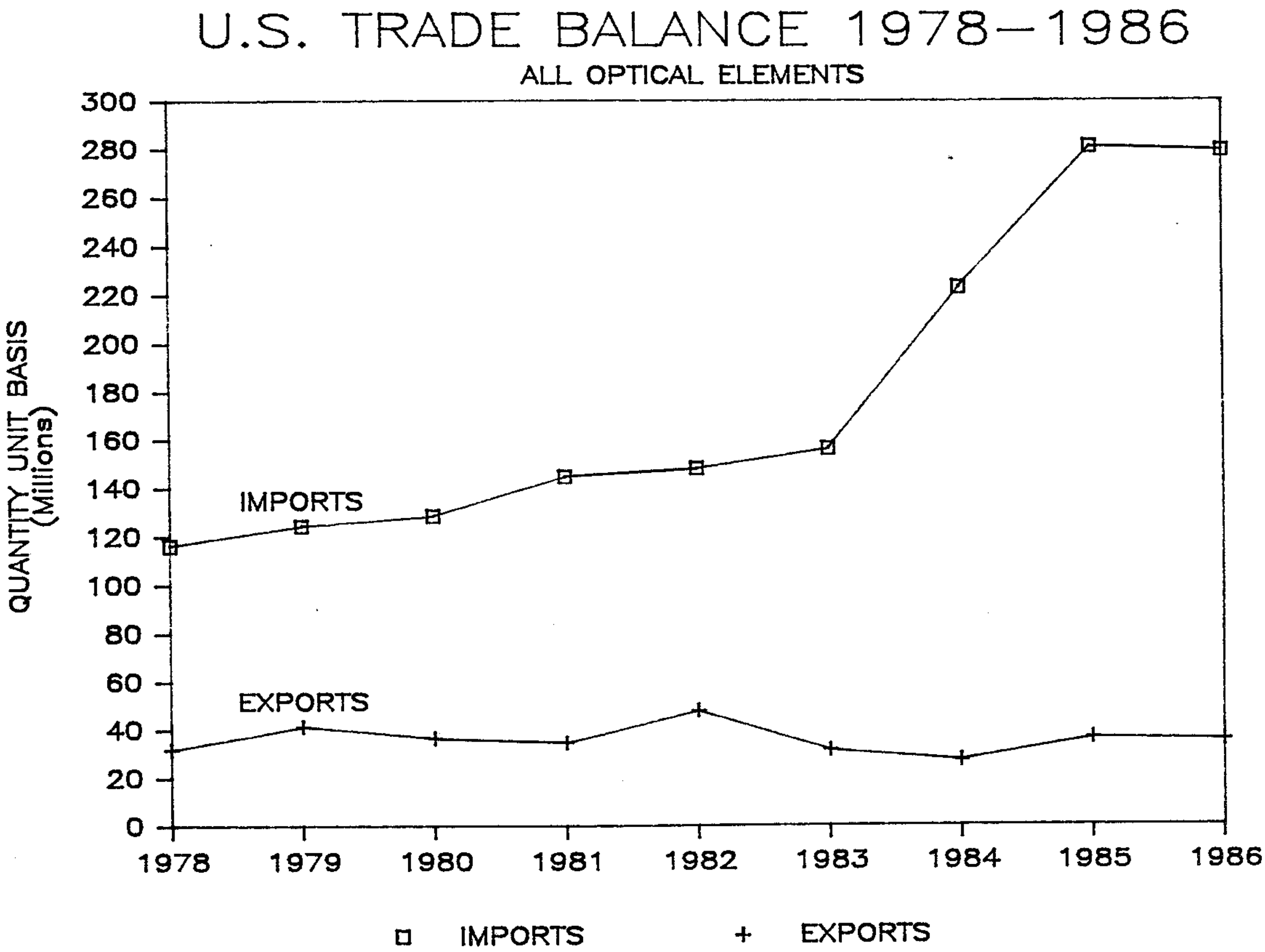
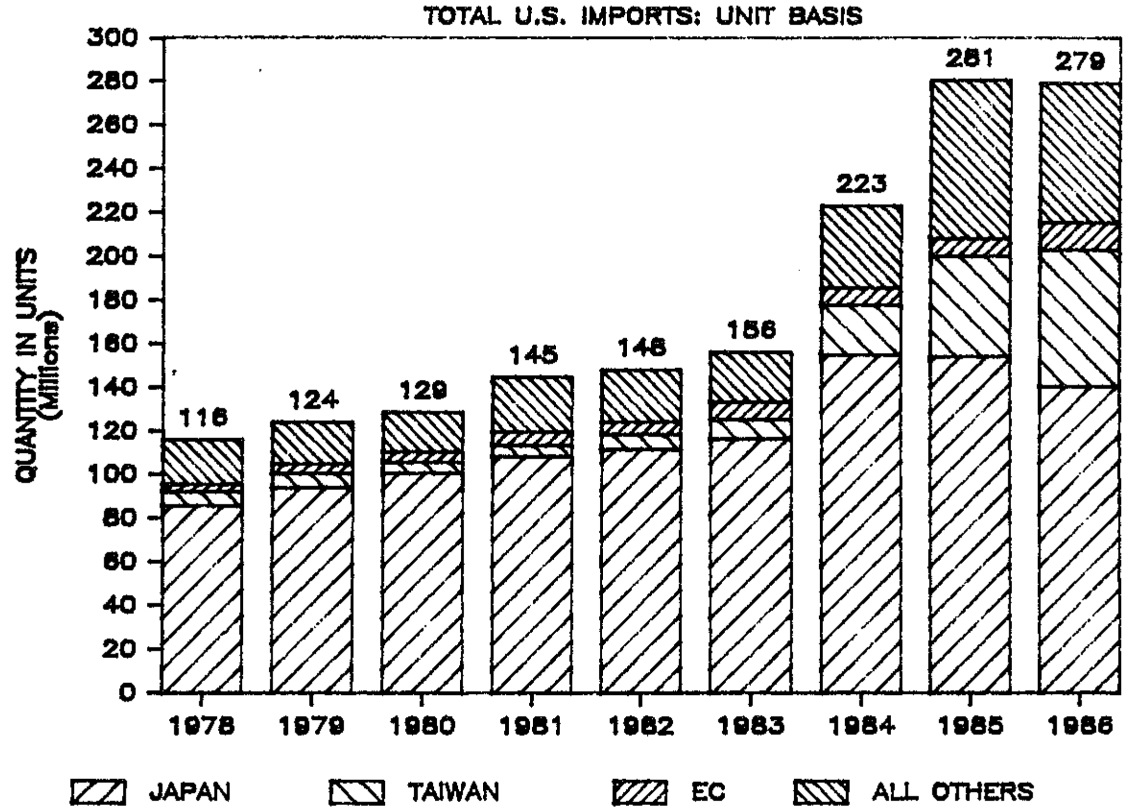

U.S. TRADE BALANCE 1978—1986
ALL OPTICAL ELEMENTS
QUANTITY UNIT BASIS (Millions)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
IMPORTS
EXPORTS
1978
1979
1980
1981
1982
1983
1984
1985
1986
IMPORTS
EXPORTS

FIGURE 2

OPTICAL ELEMENTS 1978–1986



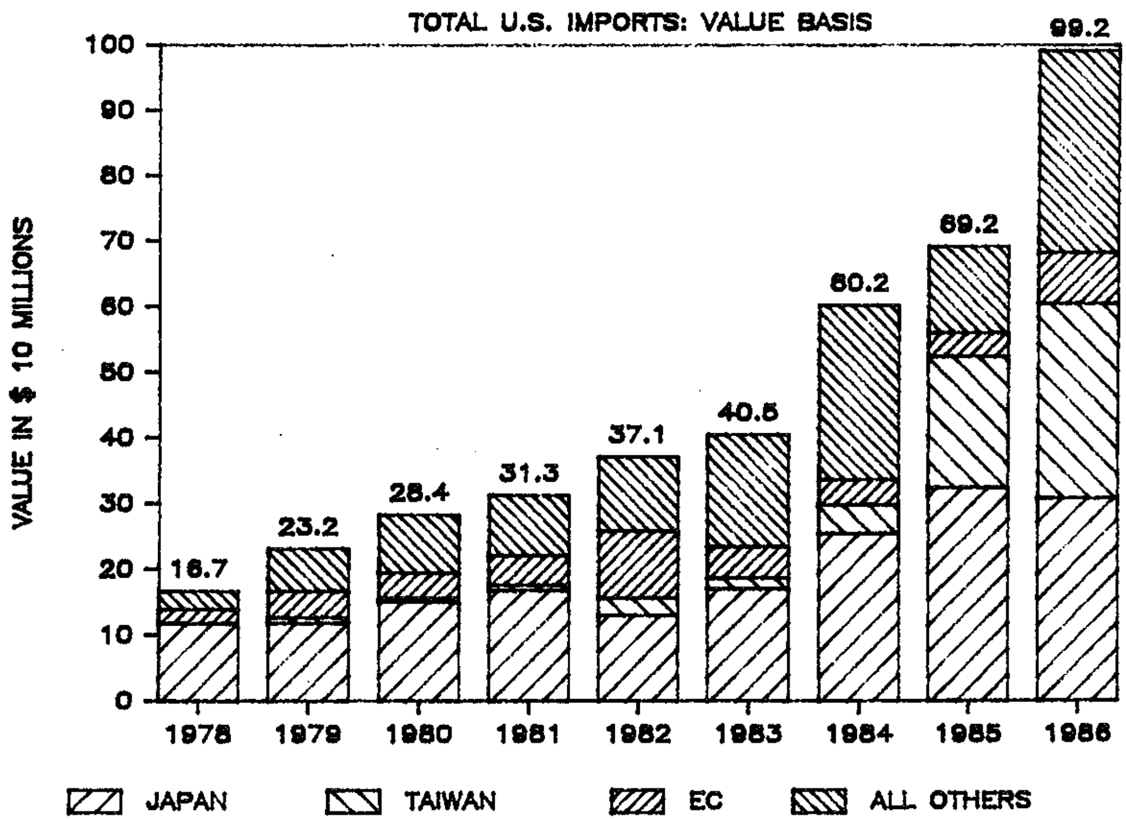


FIGURE 3

OPTICAL ELEMENTS 1978–1986

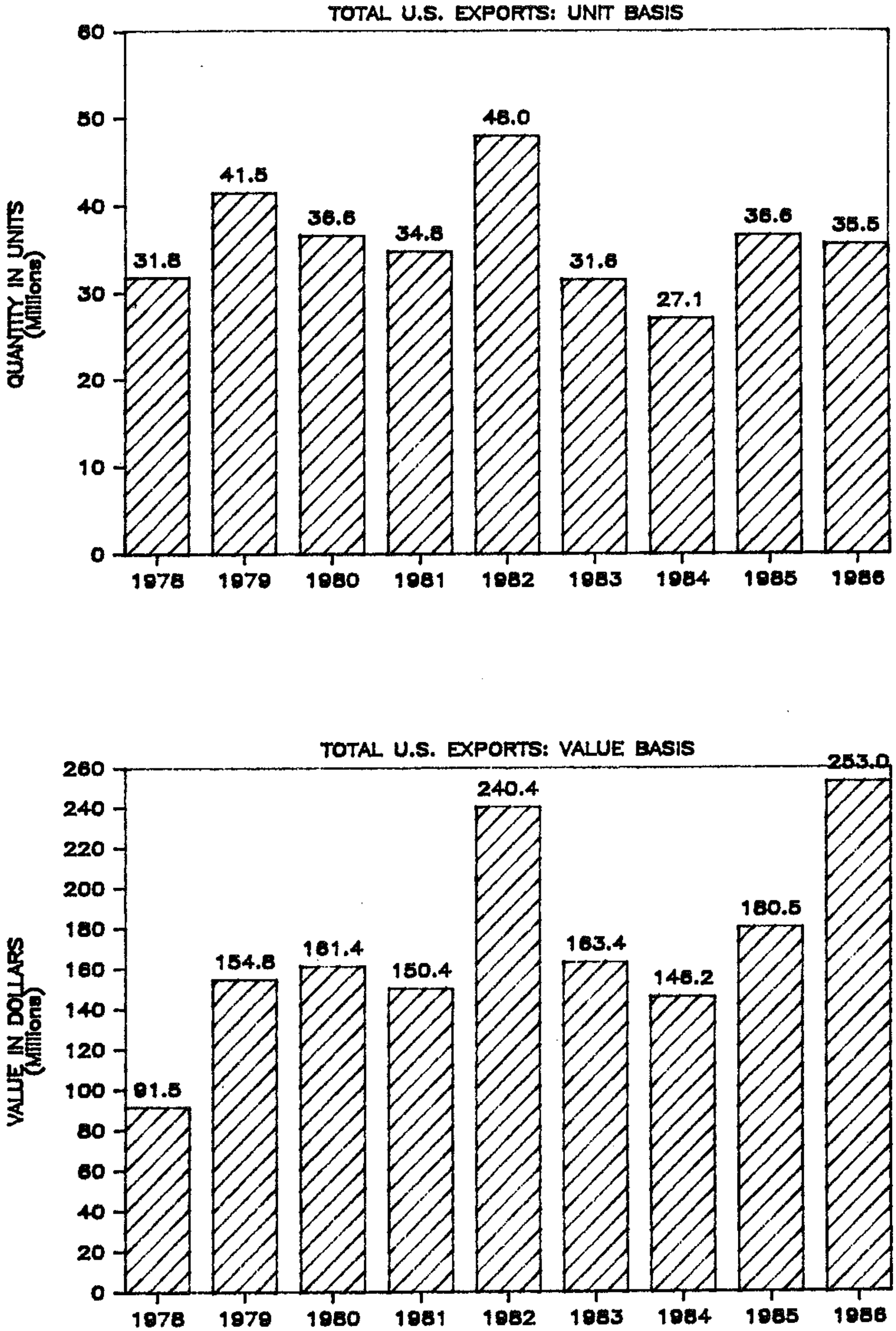
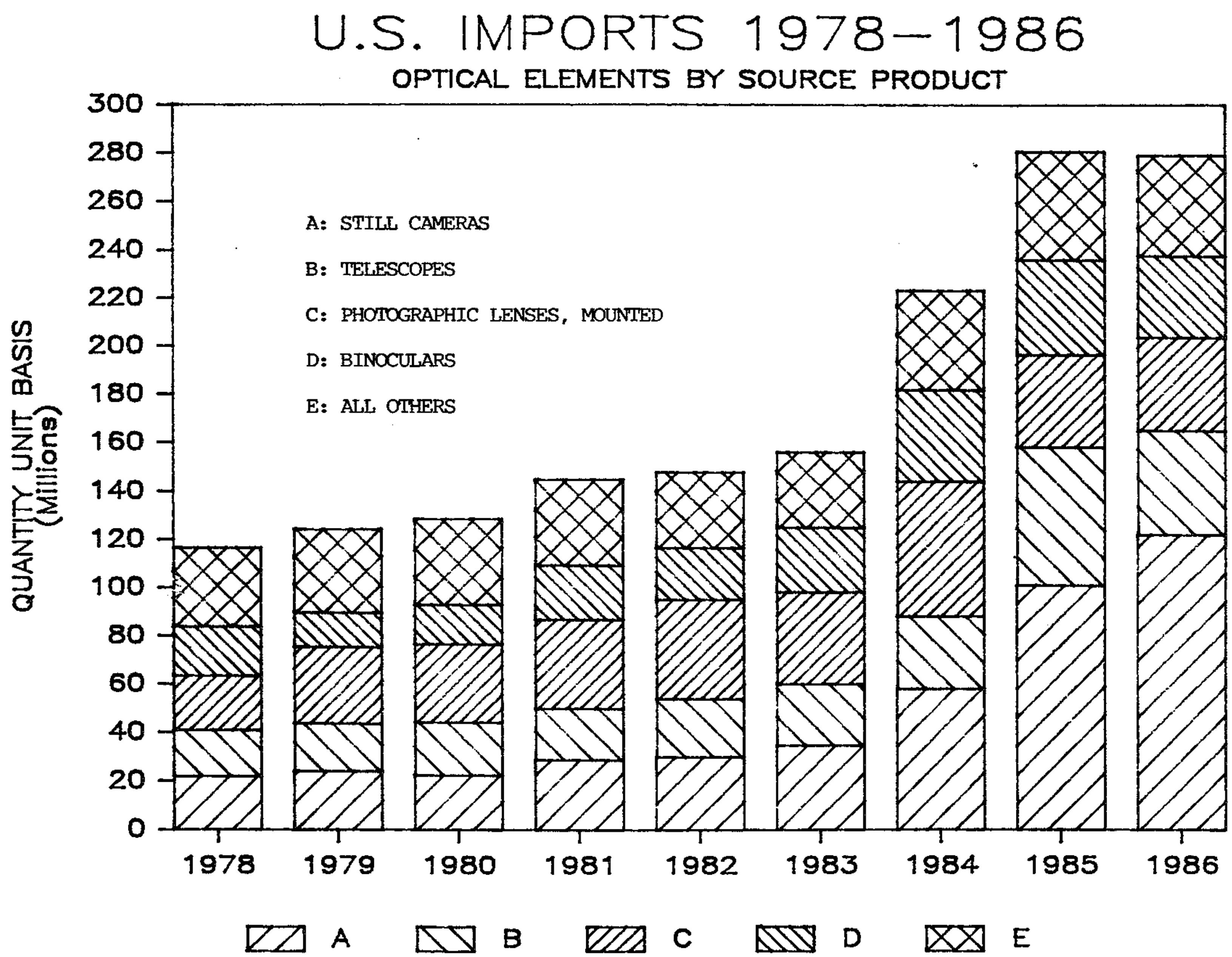


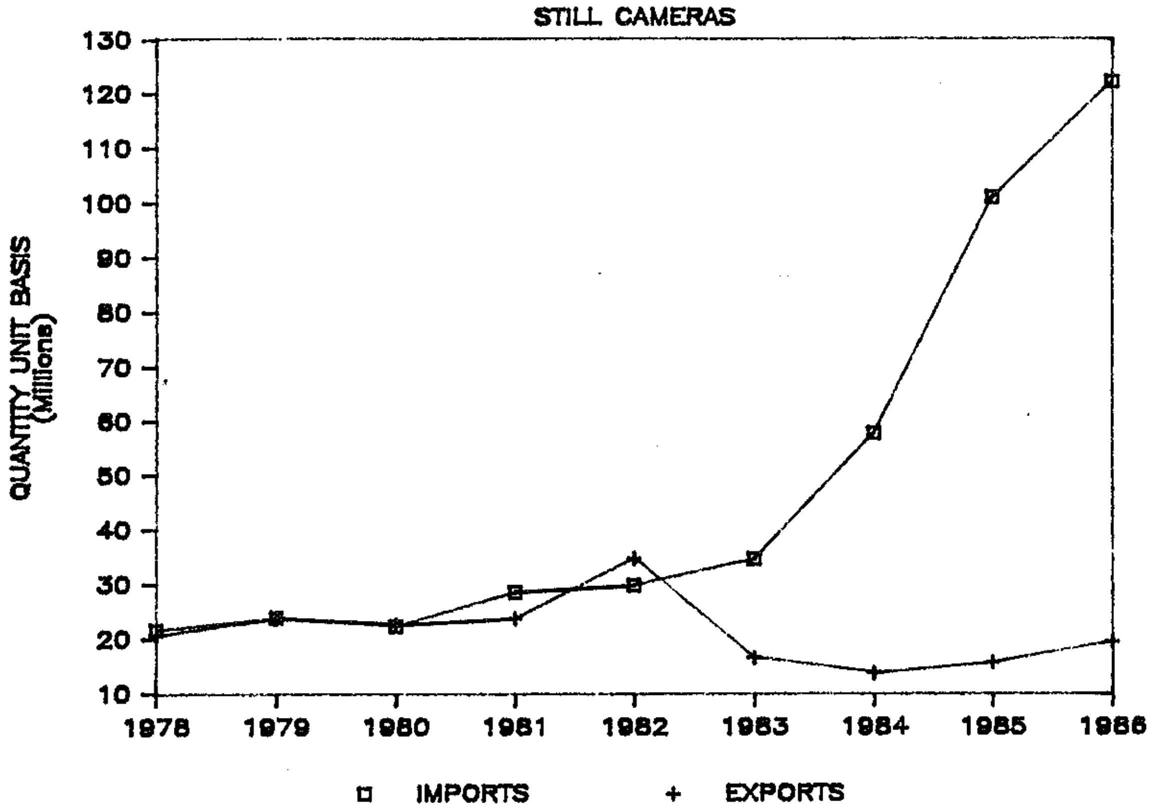
FIGURE 4



U.S. IMPORTS 1978–1986
OPTICAL ELEMENTS BY SOURCE PRODUCT
QUANTITY UNIT BASIS (Millions)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
A: STILL CAMERAS
B: TELESCOPES
C: PHOTOGRAPHIC LENSES, MOUNTED
D: BINOCULARS
E: ALL OTHERS
1978
1979
1980
1981
1982
1983
1984
1985
1986
A
B
C
D
E

FIGURE 5

U.S. TRADE BALANCE: 1978—1986



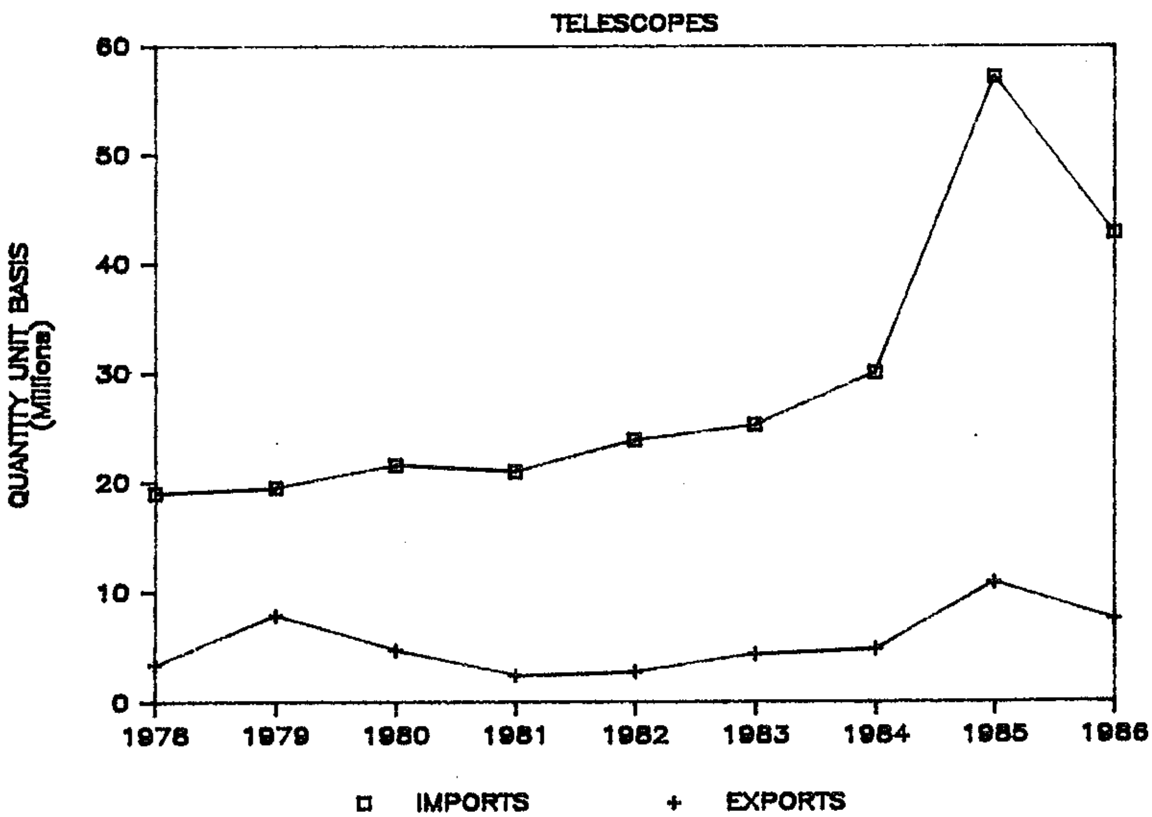
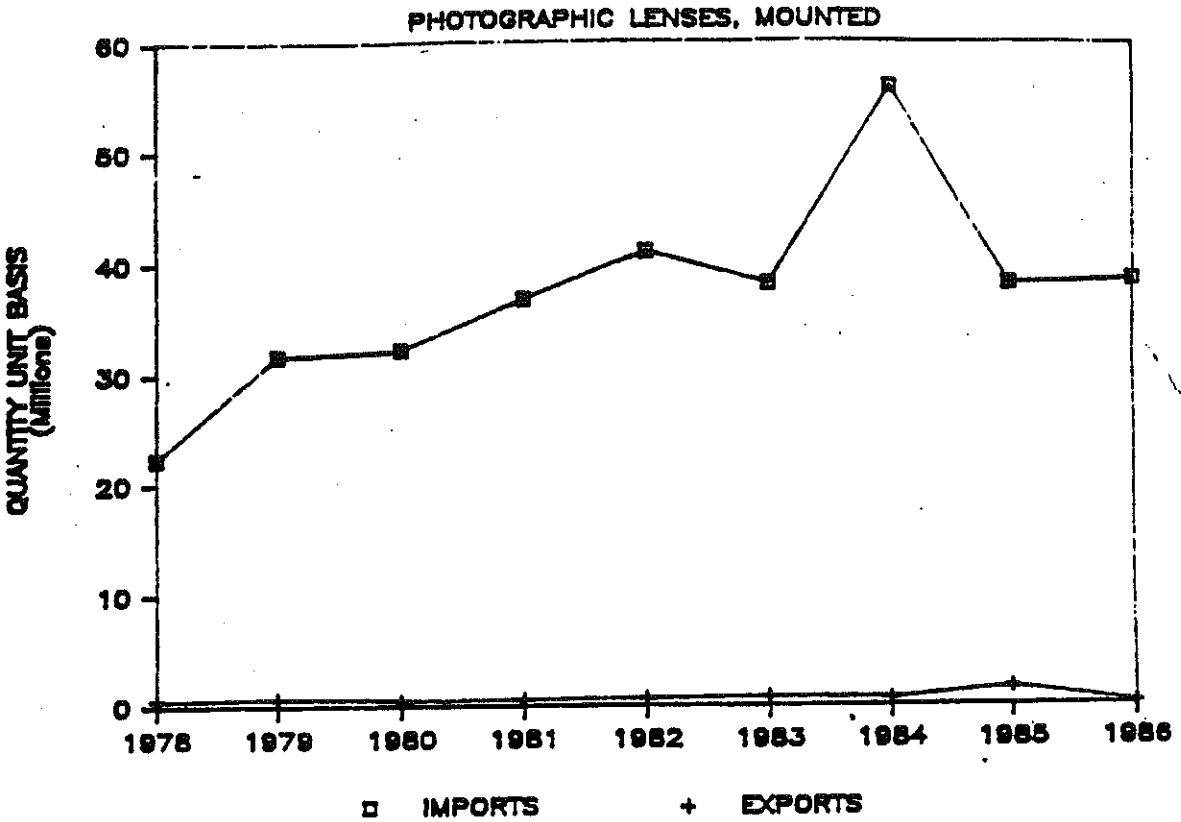
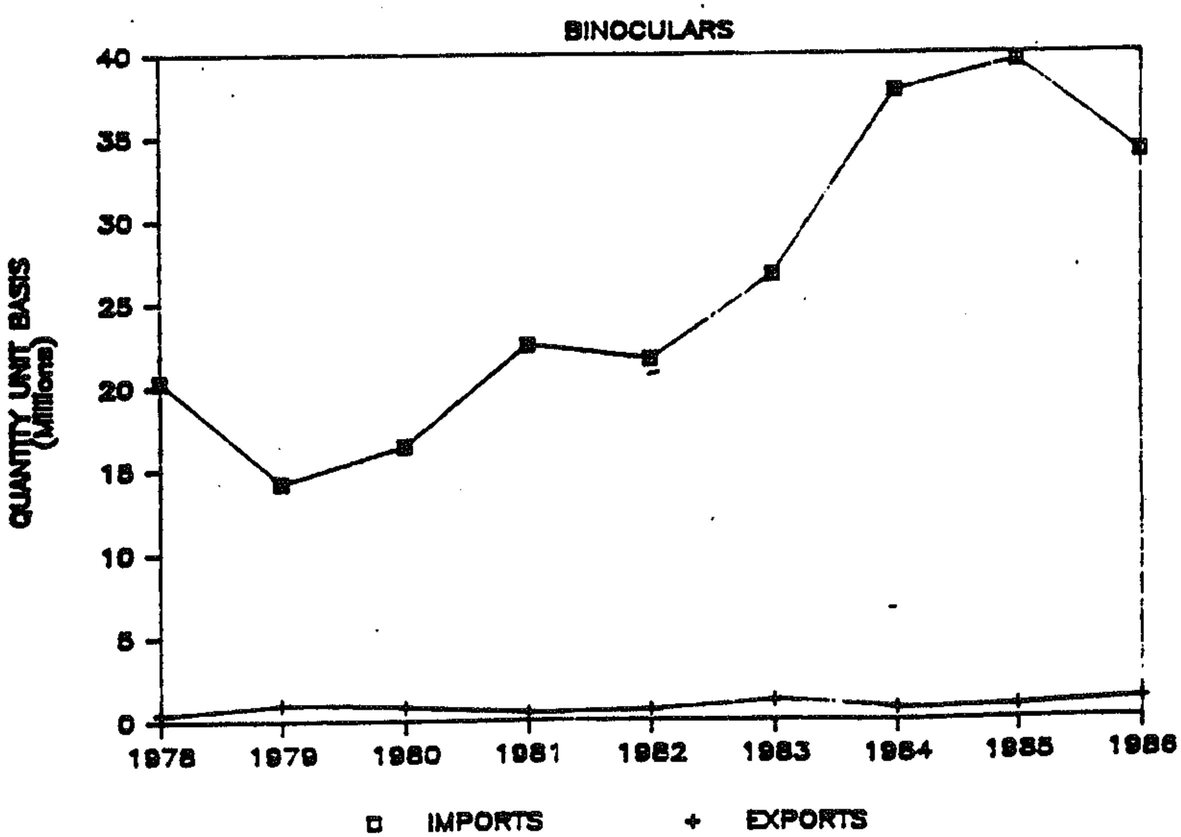


FIGURE 6


PHOTOGRAPHIC LENSES, MOUNTED
QUANTITY UNIT BASIS (Millions)
60
50
40
30
20
10
0
1978
1979
1980
1981
1982
1983
1984
1985
1986
IMPORTS
EXPORTS


BINOCULARS
QUANTITY UNIT BASIS (Millions)
40
35
30
25
20
15
10
5
0
1978
1979
1980
1981
1982
1983
1984
1985
1986
IMPORTS
EXPORTS

DEPARTMENT OF COMMERCE ★ UNITED STATES OF AMERICA ★