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Hearings on the Impact of Technology on the Workforce of the 1980's: [Testimony]

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My name is Allan Hunt. I am Acting Manager of Research at the W. E. Upjohn Institute for Employment Research in Kalamazoo, Michigan. The Upjohn Institute is an endowed, nonprofit organization that has been engaged in conducting and publishing policy-oriented research in the broad areas of employment and unemployment since 1945.

We have just completed a project on the employment implications of robotics. It was initiated at the request of the Michigan Occupational Information Coordinating Committee and reflected the keen interest within the State of Michigan in robots and their employment impacts. My colleague Timothy Hunt and I spent the last 13 months examining the employment impacts of robotics and have just published a book relating the results of that research. I will be drawing freely from this volume in my testimony today.

What is the essence of our findings? We believe the robots <u>are</u> coming; not as rapidly as anticipated by some nor with the devastating impact predicted by others, but they are coming. Furthermore, we all have a stake in the impending change, at least to the extent that robots will be part of a movement to raise the productivity of American factories and retain the competitiveness of American goods on national and international markets. We argue that robots should be regarded simply as another labor-saving technology, one more step in a process that has been going on for some 200 years.

Before proceeding it is necessary to put the so-called "robotics revolution" into some perspective. There are precious little hard data about industrial robots today. Most of the public awareness of robots has been shaped by the hyperbole in the popular press. Futurists and others compete for media attention with wild projections of the impacts of robotics--800,000 people making robots, 1.5 million technicians maintaining robots, and millions of workers displaced--with little or no consideration of the practical issues involved. We believe the intense media attention on robotics in the past year or so has seriously confused the issues.

First, we submit that the very use of the word "revolution" is inappropriate when dealing with any manufacturing process technology. Capital goods for production have long lives and are not scrapped immediately when something better comes along. Numerically controlled machine tools, usually regarded as the capital equipment most closely related to robots, expanded at a growth rate of only 12 percent for the most recent ten-year period. After 25 years, only 3 to 4 percent of all metalcutting machine tools are numerically controlled. Even digital computers, widely heralded as the most significant technological innovation of the 1960s and 1970s, expanded at a growth rate of only 25 percent (excluding microcomputers for home market). Yet many are implicitly assuming much higher growth rates for industrial robots. In terms of actual application, process technology changes tend to be evolutionary rather than revolutionary because of the physical, financial and human constraints on the rate of change of process technology.

Second, the fear of massive unemployment caused by the introduction of industrial machinery appears to be unfounded historically. Such fears began with the dawn of the industrial era in the 1700s. They are particularly acute during major recessions. For example, the "automation" problem was of urgent national concern in the early 1960s after a halting recovery from the sharp recession of 1958-59. There were grim predictions that automation was causing permanent unemployment in the auto industry and other industries. A national commission was appointed to study the problem and in 1966, with the economy near full employment, the commission rendered its final report. They concluded that a sluggish economy was the major cause of unemployment rather than automation.

Third, there appears to be a fundamental lack of understanding that the association of technological change, economic growth, and job displacement is not just a coincidence; they are intertwined and inseparable. That is not to imply that adoption of new technologies necessarily insures economic growth, or that displaced workers will always find new jobs. However, it does mean that we all have a vital stake in productivity gains (i.e., in displacing jobs) because that is what allows the possibility of rising real incomes. The price of a growing, dynamic economy that makes more goods and services available to all of us is job displacement, or the elimination of jobs through technological change.

In our book we assess the direct impact of robots on the employment picture in the U.S. and Michigan between now and 1990. Our data were gathered from published sources and through interviews with robot manufacturers, robot users, and other experts. Still, it was necessary to resort to considerable projection and estimation. This creates the opportunity to be extravagant, but we tried to avoid this. We selected the conservative, but realistic alternative wherever there was a choice. All judgments and assumptions are explicitly stated in the full monograph. Due to the space limitations here, however, the emphasis is on conclusions rather than methodology.

U.S. Robot Population

The projections of occupational impact in our research are the result of first forecasting the U.S. robot population by industry and application areas. This approach constrains the employment impacts to reflect the actual expected sales of robots. In this way a consistent economic framework is established within which it is possible to estimate not only the population of robots and job displacement but also the job creation resulting therefrom. This consistency is also very helpful in avoiding unrealistic or exaggerated conclusions. Table 1 shows our robot population forecast for 1990.

We expect strong growth in the utilization of industrial robots in the decade of the 1980s. We forecast that the total robot population in the U.S. by 1990 will range from a minimum of 50,000 to a maximum of 100,000 units. Given our estimate of the year-end 1982 population of approximately 7,000 units, that implies an average annual growth rate of between 30 and 40 percent for the eight years of the forecast period, or roughly a seven to fourteenfold increase in the total population of robots. As shown in Table 2, our forecast tends to be on the conservative side compared to other published estimates. However, the upper end of our range is generally consistent with other forecasts.

Our projected range is intended to contain the actual robot population with a high probability level, and allows for variation in interest rates, capital investment climate, auto industry recovery, and rate of economic growth. We are confident this range will contain the 1990 robot population. That means we do not expect developments such as the total collapse of the automobile industry, a major renaissance in U.S. capital investment, the early development of a significant number of nonmanufacturing robot applications, or the widespread adoption of robotics technology by small firms.

The U.S. population of robots is developed separately for the auto industry and all other manufacturing. This is partly to take advantage of the fact that the auto producers have announced goals for robot installations which could be factored into our robot population forecast. It also reflects the fact that the major impact of robots in the State of Michigan will be in the auto industry. Our forecast sees 15,000 to 25,000 robots employed in the U.S. auto industry by 1990. If the auto firms were to exactly meet their announced plans, there would be approximately 20,000 robots in U.S. auto plants by 1990.

Job Displacement

Utilizing the robot forecast by industry, and the assumption of a gross displacement rate of two jobs per robot which was strongly supported in our interviews, estimates of gross job displacement (the elimination of job tasks rather than actual layoffs of workers) can be derived. We estimate that robots in the U.S. will eliminate between 100,000 and 200,000 jobs by 1990. From 30,000 to 50,000 of these will be in the auto industry, while 70,000 to 150,000 jobs in other manufacturing industries will also be eliminated.

In addition to the assignment of robots by industry, it was necessary to forecast the applications for which they will be used. This is required if the robot population forecast is to be useful in predicting occupational displacement. Otherwise there is no way to connect the robots with the work content of specific jobs. The application areas used in our research are welding, assembly, painting, machine loading and unloading, and other.

When the robot forecast by application area and industry is matched against an occupational data base similarly organized, specific occupational displacement rates can be estimated. These results are shown in Table 3. Although the maximum overall job displacement rate in manufacturing of 1 percent through 1990 is not particularly problematical, specific industry and occupation displacement rates are very significant, even dramatic.

To begin with, the displacement rate derived for the auto industry ranged from 4 to 6 percent of all employment. But when displacement was calculated only against the production workers in the auto industry, the magnitude of displacement was from 6 to 11 percent. Even when considered to be over a period of a decade, these rates of job displacement are significant.

When specific occupational displacement rates are calculated, even more striking results emerge. Our results suggest that between 15 and 20 percent of the welders in the auto industry will be displaced by robots by 1990. Even more dramatically, between 27 and 37 percent of the production painter jobs in the auto industry will be eliminated by 1990. While displacement results are generally less significant for specific occupations in all other manufacturing, it is projected that 7 to 12 percent of the production painter jobs there will be lost in the same time frame.

The conclusion of the job displacement estimates is that while job displacement due to robots will not be a general problem before 1990, there will clearly be particular areas that will be significantly affected. Chief among these will be the painting and welding jobs for which today's robots are so well adapted. Lesser impacts will be apparent on metalworking machine operatives and assemblers. Geographically, states such as Michigan, especially the southeastern quadrant with its heavy dependence on autos, will suffer greater displacement than other states or regions.

We do not believe that this job displacement will lead to widespread job loss among the currently employed, however. Table 4 compares the average annual rates of displacement by occupation with the Bureau of Labor Statistics estimates of average annual replacement needs and total job openings for the same occupational groups. Clearly, the job displacement which can be expected is much less than the occupational replacement needs for the foreseeable future. Even in the auto industry, voluntary turnover rates historically have been sufficient to handle the reduction in force that might be required. In addition, the new General Motors-United Auto Workers contract, as one example, seems to provide adequate job security assurances, and the retraining commitment necessary to back them up. Thus we do not expect any substantial number of auto workers to be thrown out of work due to the application of robots. Any unemployment impact is likely to be felt by the unskilled labor market entrants who will find more and more factory gates closed to the new employee. Therefore, if there is an increase in unemployment as a result of the spread of robotics technology, we fear the burden will fall on the less experienced, less well educated part of our labor force.

Job Creation

Turning our attention to the job creation issue, we forecast the direct creation of about 32,000 to 64,000 jobs in the U.S. by 1990 in four broad areas: robot manufacturing, direct suppliers to robot manufacturers, robot systems engineering, and corporate robot users. The jobs in corporate robot users identify maintenance requirements for robots, while the jobs in robot systems engineering identify the applications engineering requirements for robot systems, without regard to industry of employment.

In these projections we assumed that the status quo would be maintained in both the import and export markets for robots, primarily because of a lack of any better information. But there is certainly no guarantee that U.S. producers will maintain their share of the national or worldwide market. This threat is especially menacing because of Japanese and European expertise in robotics technology.

The projections of robot-related job creation by occupation are very speculative because of the limited experience to date with robots and the uncertainties involved in predicting the future occupational profiles of firms that do not yet exist. However, the high technical component of labor demand is quite startling. It can be seen from Table 5 that well over half of the jobs created will require two or more years of college training.

The largest single occupational group of jobs created by robotics will be robotics technicians. This is a term which is just coming into general usage; it refers to an individual with the training or experience to test, program, install, troubleshoot, or maintain industrial robots. We anticipate that most of the new entrants to this occupation will be trained in community college programs of two years duration. We project that jobs for about 12,000 to 25,000 robotics technicians will be created in the U.S. by 1990. We do not anticipate a supply problem for robotics technicians, as the community college system gives every indication that they will be ready and willing to train whatever numbers are needed. In fact, our current concern is that they may, in some instances, be increasing the supply too rapidly.

Specifically, a continuation of the expansion of the last year or so in course offerings and enrollments in robotics technician programs on a national scale will very quickly swamp the ability of the industry to absorb trained people. There may already be as many students enrolled in these programs as there are annual sales of robots. For that reason, we endorse careful attention to the breadth of training. A firm grounding in theory and general principles of electronics, controls, hydraulics, etc. will stand the graduates of such programs in good stead whether they actually work primarily with robots or not.

In the auto industry, we expect the robot maintenance requirement will continue to be met by the members of the UAW Skilled Trades Council. General Motors already has agreed to a retraining effort in excess of $80 million annually. We believe the strong implication of the contractual arrangements is that auto industry employers will not be required to hire from the outside to meet their robotics technician needs. Other major robot users may follow the lead of the auto industry, but it is impossible to predict that with assurance at this early date.

There also will be a relatively large number of graduate engineers needed to implement the expansion of robotics technology in U.S. industry. We estimated the requirement from about 4,600 to 9,300 new engineers. While these numbers are comparatively small, only one-fifth of one year's production of engineers at the baccalaureate level, there is already a clear shortage of engineers, so we start from a deficit position. In addition, we face the challenge of other likely engineering demand increases as well as the historical instability of engineering enrollments. Thus it is quite likely that a shortage of engineers could compromise the expansion of robotics technology. Thus we add our voices to those calling for immediate national attention to the supply of engineers.

The most remarkable thing about the job displacement and job creation impacts of industrial robots is not the fact that more jobs are eliminated than created; this follows from the fact that robots are labor-saving technology designed to raise productivity and lower costs of production. Rather, it is the skill-twist that emerges so clearly when the jobs eliminated are compared to the jobs created. The jobs eliminated are semi-skilled or unskilled, while the jobs created require significant technical background. We submit that this is the true meaning of the so-called robotics revolution.

Policy Implications

We suspect that these research results on the impact of robotics can be generalized to other so-called "high-tech" areas. Data Resources, Inc. (DRI) has produced a forecast for Business Week of the employment potential of the 92 SIC codes labeled high technology or high-tech-intensive by the BLS. For the period 1983 to 1993, DRI projects 730,000 to 1 million jobs will be created in this sector. This is about half the decline in manufacturing employment we have suffered in the past three years due to the recession.

The most fundamental reason these high-tech employment areas will not dominate in the near future is because they are so small now. We estimate there are only 5,000 to 6,000 people employed in robotics today; only about 2,000 of these in robot manufacturing. The situation is similar for other emerging high technology industries. "High-tech hysteria" notwithstanding, we are confident that there will be more jobs created in Michigan by economic recovery than by high technology for at least the next decade.

We also believe, however, that the changes created by the introduction of the microprocessor to U.S. manufacturing in the future will alter the occupational content of the demand for labor. This will not happen overnight; it will be an evolutionary change. In fact, the skill-twist in the U.S. economy has been occurring over the past 40 years or so. We believe there will be less and less opportunity for employment by the unskilled or the semi-literate in our economy in the future. Thus while robotics and the other new manufacturing technologies do not create an immediate human resource problem, over time they will add to our existing problem; an oversupply of unskilled labor relative to demand.

When the Manpower Development and Training Act was passed by the Congress in 1962, it was designed primarily to attack the problem of technological unemployment. But as Willard Wirtz (Secretary of Labor, 1961-1969) puts it, we quickly discovered we were working on the wrong woodpile. We did not have a fundamental need for retraining of workers whose skills had been rendered obsolete by automation; we faced a growing pool of labor (especially disadvantaged youth) who had never acquired any skills in the first place.

Similarly in 1983, we believe the prophets of high-tech hysteria are fundamentally misdiagnosing the problem. We do not have an enormous displaced worker problem, if by that term one refers to workers who had good jobs with substantial seniority who have been permanently separated from their employer. The truly displaced workers, in our opinion, are those involved in plant closing situations, not simple layoff due to lagging sales. We need a coherent human resource policy to deal with the very difficult problems associated with plant closure. Hopefully the JTPA displaced worker program will evolve in that direction as local decision-makers implement actual programs.

We believe a major share of what is popularly labeled the displaced or dislocated worker problem is purely cyclical and will disappear with an adequate economic recovery. The truly structural problems will remain, however, in the face of a job market which will increasingly require significant skills for entry level employment.

Historically in the United States, we have followed a market allocation strategy for human resources. Individuals prepare themselves for the job market as they see fit. Even though substantial public subsidies may be involved, there has not been any effective planning or coordination involved. We allow students to choose their own careers with minimal constraints and only the vaguest informational support. It is not necessary to abandon this non-system, but it is necessary to make it more efficient in the task of allocating scarce resources. Human resource decisions made by individuals can be made more effective with the provision of up-to-date and reliable labor market information. In addition, many youth have not made any decision, but simply followed the path of least resistance. Increasingly this path will lead to a dead end.

We cannot perfectly anticipate future occupational needs in great detail. It would be difficult in a planned economy; it is impossible in a market economy. There are too many influences on market events to make them predictable in advance. We can, however, improve our efforts to provide intelligence about general trends and to project their direction. The problem has been that there was no adequate data base with which to discern trends as they emerged. Until very recently we were dependent on decennial census data for detail on the occupational content of our economy. Measurements ten years apart are simply not sufficient to the task, especially when the method of classification was changed with each observation as well.

I believe that the Occupational Employment Statistics (OES) survey program can provide an adequate remedy to this lack of information, if appropriately funded and developed. This would include not only the data gathering and analysis (which must be speeded up greatly if its usefulness is to be maximized) but the dissemination of the information to individual decision-makers. At a minimum, we need national projections and local data bases sufficient to make the local implications of the larger picture apparent.

The evidence on the performance of job search skills training, job clubs, and the like is sufficient to convince me that there are very significant frictional barriers to employment for some. An improved labor market information system is requisite to better performance in this area. In addition, an adequate up-to-date data base for local labor market areas would be of inestimable assistance for planning JTPA and other local training efforts. Such a data base must have sufficient occupational detail to make it useful in projecting the need for particular skills, but not so much detail that it is confusing. Again, the OES data base possesses considerable promise as a prototype for this effort.

In addition, I believe we must provide a better educational opportunity in the first instance, and move to insure that our youth take advantage of this opportunity. We must upgrade our science and technology training all along the educational continuum. We need a new national effort similar to the National Defense Education Act to upgrade preparation for the world of work. We also need the techniques and the resources to insure that all our youth acquire some useful human capital. At a minimum, we should make sure that they have sufficient skills so that they can be retrained someday, if necessary. This means basic skills like reading, writing and arithmetic. I would favor competency-based standards in these areas for high school graduation.

One hopeful element here is the development of computerized individualized instructional systems in the last few years. Such systems would seem to offer great potential for teaching a large number of skills in non-classroom environments. There should be more effort directed to developing and implementing such systems. They would of course be useful for displaced workers as well. General Motors has found the Plato system, for example, very useful in retraining older workers who do not adapt well to a traditional classroom environment.

It does not make sense that we offer special tax incentives for physical capital formation only. If one wishes to make an investment in physical capital today, there are investment tax credits, rapid depreciation through the accelerated cost recovery system, and other public subsidies available. But if one wants to invest in one's own human capital, it is only deductible if it is required as minimal preparation for the job now held. If an individual wishes to improve his/her position, s/he must bear the full private cost of such investment. This is illogical and counterproductive. Individuals and firms should receive tax credit subsidies to encourage private investment in human capital. This simple step would signal the social interest in such investment and help offset the rising cost of education due to declining direct public subsidies.

Hopeful Signs for the Future

I would like to conclude my testimony by citing some developments that have occurred or are about to occur that promise some relief from our current situation. First, and most important, I believe the signs are now unmistakable that the bottom of the recession is behind us and economic conditions will be improving. Approximately 15 percent of the laid-off auto workers have already been recalled and I believe the prospects are good for further recalls. Interest rates are down, prices are not up substantially, and tastes seem to be changing back to larger cars in the wake of stabilized oil prices.

Second, the demographic trends in the next decade appear to be favorable for reducing the additions to the labor force. While the number of youth (ages 16-24) in the labor force increased by 54 percent from 1960 to 1970 and 38 percent from 1970 to 1980, this component will actually decrease by 14 percent in the decade of the 1980s. If we can insure that a large proportion of youth entering the labor force in the '80s are prepared for the world of work, we may be able to keep from adding to the existing unemployment problem.

Third, there is widespread evidence of recognition that we have some significant human resource problems. The recent Commission report on the quality of our educational effort is but the latest example. There has been dissatisfaction with our educational performance from a number of perspectives. Perhaps this report will help bring the debate to a policy decision.

Last, there is at least a chance that the increasing incidence of labor-management cooperation in the last few years may be permanent. This is significant because of the potential productivity improvement that can accompany increased cooperation between management and labor. Japanese workers may not work any harder or any smarter than American workers, but everyone seems to agree they do work more cooperatively.

Ultimately, there is only one satisfactory solution to the high cost of labor in the U.S. since this is also the basis for the American standard of living. That solution lies in the productivity of our human resources. If we are to continue to be paid more than workers in other countries, we must produce more than they do. Careful management of our human resources is the only way I know to accomplish that.

Thank you for your attention.

Table 1

Forecast of U.S. Robot Population by Application, 1990

Application	Autos		All other manufacturing		Total	
	Range of estimate		Range of estimate		Range of estimate	
	Low	High	Low	High	Low	High
Welding	3,200 (21.3%)	4,100 (16.4%)	5,500 (15.7%)	10,000 (13.3%)	8,700 (17.4%)	14,100 (14.1%)
Assembly	4,200 (28.0%)	8,800 (35.2%)	5,000 (14.3%)	15,000 (20.0%)	9,200 (18.4%)	23,800 (23.8%)
Painting	1,800 (12.0%)	2,500 (10.0%)	3,200 (9.1%)	5,500 (7.3%)	5,000 (10.0%)	8,000 (8.0%)
Machine loading/unloading	5,000 (33.3%)	8,000 (32.0%)	17,500 (50.0%)	34,000 (46.0%)	22,500 (45.0%)	42,000 (42.0%)
Other	800 (5.3%)	1,600 (6.4%)	3,800 (10.9%)	10,500 (14.0%)	4,600 (9.2%)	12,100 (12.1%)
Total	15,000	25,000	35,000	75,000	50,000	100,000

Table 2

Selected Estimates of 1990 Sales, Population and Growth Rates of Robots in the U.S.

Source	Unit sales 1990	Value (billions) (1980 $)	1980-90 annual growth rate (percent)	Cumulative population
Conigliaro[a]	31,350	2.0+	38	122,000
Aron[b]	21,575	1.9	36	94-95,000
UM/SME Delphi[c]	33,333	2.0+	45	150,000
Engelberger[d]	40,000	-	35	150,000
RIA[e]	-	-	35-39	75-100,000

NOTE: The 1980-90 annual growth rate and the cumulative population in 1990 are not necessarily stated directly in all of these studies but can be calculated from data that are provided.

a. Laura Conigliaro, *Robotics Newsletter*, Prudential-Bache Securities Inc., January 15, 1982, p. 7 and June 19, 1981, p. 8.

b. Paul Aron, "Robots Revisited: One Year Later," in *Exploratory Workshop on the Social Impacts of Robotics: Summary and Issues*, Office of Technology Assessment, U.S. Government Printing Office, Washington, DC, July 1981, p. 34.

c. Donald N. Smith and Richard C. Wilson, *Industrial Robots: A Delphi Forecast of Markets and Technology*, Society of Manufacturing Engineers, Dearborn, Michigan, 1982, pp. 47-51, and Donald N. Smith, Peter G. Heytler, and Murry D. Wikol, "Sociological Effects of the Introduction of Robots in U.S. Manufacturing Industry," Industrial Development Division, Institute of Science and Technology, University of Michigan, Ann Arbor, Michigan. Unpublished paper presented at the *CAMPRO '82 Conference on Computer Aided Manufacturing and Productivity*, October 1982, p. 7.

d. Joseph L. Engelberger, *Robotics in Practice*, American Management Association, AMACOM Press, New York, 1980, p. 115.

e. Robot Institute of America, *RIA Worldwide Survey and Directory on Industrial Robots*, Dearborn, Michigan, 1981, p. 30.

Table 3

Displacement Impact of Robots in the United States by Application, Cumulative 1980 to 1990

	Autos		All other manufacturing		Total	
Application	1980 employment level	Displacement range (percent)	1980 employment level	Displacement range (percent)	1980 employment level	Displacement range (percent)
Welding	41,159	15 - 20	359,470	3 - 6	400,629	4 - 7
Assembly	175,922	5 - 10	1,485,228	1 - 2	1,661,150	1 - 3
Painting	13,556	27 - 37	92,622	7 - 12	106,178	9 - 15
Machine loading/ unloading	80,725	12 - 20	988,815	3 - 7	1,069,540	4 - 8
All operatives and laborers	467,846	6 - 11	9,954,048	1 - 2	10,421,894	1 - 2
All employment	773,797	4 - 6	19,587,771	0 - 1	20,361,568	0 - 1

SOURCE: Employment data based upon unpublished OES data provided by Office of Economic Growth and Employment Projections, Bureau of Labor Statistics, U.S. Department of Labor, Washington, DC.

Table 4

Displacement Impacts of Robots Compared to BLS Estimates of Job Openings

Application	Simple average annual displacement impact of robots 1980 - 1990*			BLS average annual replacement needs 1978 - 1990	BLS total average annual openings 1978 - 1990
	Autos	All other manufacturing	Total	All industries	All industries
Welding	2.0	.6	.7	2.3	5.1
Assembly	1.0	.2	.3	3.0	6.5
Painting	3.7	1.2	1.5	2.4	3.9
Maching loading/ unloading	2.0	.7	.8	2.5	3.0
All operatives and laborers	1.1	.2	.2	2.9	4.0
All employment	.7	.1	.1	3.8	5.5

SOURCE: Replacement needs and total average annual openings from *The National Industry-Occupation Employment Matrix, 1970-1978, and Projected 1990*, U.S. Department of Labor, Bureau of Labor Statistics, Bulletin 2086, Vol. 2, April 1981, pp. 495-502.

*Assuming maximum growth in robot population.

Table 5

Direct Job Creation in U.S. Due to Robotics, by Occupation, 1990

Occupation	Employment: Range of estimate Low	High
Engineers	4,636	9,272
Robotics technicians	12,284	24,568
Other engineering technicians	664	1,328
All other professional and technical workers	936	1,871
Managers, officials, proprietors	1,583	3,166
Sales workers	581	1,162
Clerical workers	2,908	5,817
Skilled craft and related workers	2,163	4,326
Semi-skilled metalworking operatives	2,153	4,306
Assemblers and all other operatives	3,763	7,526
Service workers	138	276
Laborers	279	558
Total	32,088	64,176