DEPARTMENT OF INDUSTRY • MATERIALS BRANCH

COMMERCIAL METAL HEAT TREATING FACILITIES IN CANADA

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CANADA

DEPARTMENT
OF
INDUSTRY

This report is the first in a series of publications, dealing with specific sectors of the Canadian metal and mineral industries, prepared by the Materials Branch.

It is designed to fulfil one of our many objectives, outlined in the Department of Industry Act, by assisting our manufacturing industry in developing expansion opportunities.

The report is an example of the type of projects undertaken by the Materials Branch and it is our hope that it will be both useful and informative.

R.D. Hindson,
Director.

CANADA

MINISTÈRE
DE
L'INDUSTRIE

Ce rapport est le premier d'une série de publications, préparées par la direction des matériaux, concernant certains groupes d'industries métallurgiques et minières canadiennes.

Il est préparé dans le but de réaliser l'un des nombreux objectifs, qui sont décrits dans l'Acte du Ministère de l'Industrie, en aidant notre industrie de fabrication à créer de nouvelles opportunités d'expansion industrielle.

Ce rapport est un exemple du genre de projets entrepris par la direction des matériaux. Nous espérons qu'il sera utile et instructif pour le lecteur.

R.D. Hindson,
Directeur.

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FOREWORD

The information in this publication has been gathered as a result of an industry survey and is presented with the intended purpose of serving as a convenient reference for users of heat-treating services in locating suitable suppliers. Furthermore, by listing the capabilities and limitations of the the existing commercial heat-treating facilities in Canada, this publication should assist Canadian firms in identifying potential areas of future business expansion.

It was not the aim of this project to list all metal heat-treating facilities available in many large industrial corporations, serving the exclusive purpose of processing a specific proprietary line of products. Only facilities reported as being at least partially available for commercial heat-treating of a multiple range of products were considered.

Part I of this publication reviews the most recent developments in the commercial metal heat-treating field, highlighting unusual additions and expansions which resulted in a higher degree of our self-sufficiency in this vital industrial sector.

Part II provides a detailed list of metal heat-treating equipment and subsidiary facilities of each Canadian firm.

Part III is devoted to brief explanations of the heat-treating processes generally employed in processing carbon and alloy steels, aluminum, copper, magnesium, nickel and titanium alloys. Its main purpose is to assist in uniform interpretation of the metallurgical terminology employed in describing various processes.

The cooperation of the Canadian heat-treating firms in providing detailed data on their facilities is hereby gratefully acknowledged.

PART I

INTRODUCTION

The need to keep abreast of new technological and engineering developments is probably nowhere as pronounced as in the metal processing field. In shaping and treating of metals into many useful products and components heat-treatment plays a vital role by modifying their structural and physical characteristics and thus assuring the availability of products unobtainable in the past.

While new alloying combinations are being devised, familiar metals and alloys are being improved, and all metals and their alloys are being asked to meet increasingly difficult specifications and service conditions. At the same time traditional products, skills and facilities are rapidly becoming obsolete.

The growth of the commercial heat-treating industry in Canada has been gradual but unspectacular. For long years its existence depended on tool-and-die makers, machine shops and occasional business from fabricators.

Increasing reliance on domestic sources for various components for aircraft, automotive and machinery building industries stimulated the growth of older, and the establishment of new, heat-treating firms with specialized knowledge and facilities to serve a specific industrial sector.

The concentration of heavy industry in the south-eastern Ontario and the western Quebec regions was primarily responsible for the establishment in these areas of a selective group of firms with the most elaborate heat-treating facilities. Several firms in Kitchener-Oakville-Toronto areas have advanced technological knowledge and up-to-date facilities for heat-treating and joining the most elaborate components in a variety of metals and alloys.

Canadian self-sufficiency in the field of constructional and abrasion-resistant steel plates and sheets has been substantially enhanced by a new business venture in Richmond Hill, Ontario. The requirements of Canadian markets for heat-treated low alloy steel plate and sheet used in mining, construction and fabrication industries can now be supplied from domestic sources. The availability of Canadian abrasion-resistant steels with high hardness and impact resistance combined with good weldability and formability, and at a competitive cost, should be a significant factor in gradual replacement of present imports.

A somewhat less advanced selection of commercial heat-treating facilities is available in Quebec and the Maritime Provinces. In these areas the type of metal working industry appears to favour captive in-plant facilities suitable for processing specific product lines.

A limited scope of the metal working industry in the western provinces at present does not appear to justify the expansion of independent heat-treaters.

The prosperity of this industry is strongly dependent on the ability of individual firms to keep pace with the latest developments in new heat-treating equipment, controls and atmospheres. New continuous processing lines with sophisticated controls and modern batch heat-treating furnaces equipped with suitable protective atmosphere generators are rapidly replacing makeshift facilities.

Auxiliary devices, such as dewpoint controls and multipoint infrared analysers, are being installed by the equipment makers as standard equipment. Atmosphere tempering furnaces to accompany controlled atmosphere hardening are becoming economical for mass processing applications. Instruments, based on gas chromatographic techniques, are available for continuous analysis of several gas components simultaneously.

Equipment manufacturers may be credited with the expanded use of austempering and martempering techniques. Producers of quenching oils and heat-treating salts have contributed their share by developing more advanced, economical and safer heating and quenching media.

By employing innovations of processing techniques, combined with more thorough understanding of metallurgical phenomena, a wider application of more conventional materials is being achieved. Metallurgists have obtained fatigue properties in heat-treated carbon steels superior to those developed in alloy grades by careful selection of steel composition coupled with controlled heating and drastic but accurate quenching rates.

The advent of vacuum heat-treating and brazing opened significant possibilities in making standard industrial metals of such highly reactive materials as titanium, zirconium, vanadium and others. Today vacuum techniques are being employed for many conventional alloys, such as air hardening of tool steels and bright annealing of stainless steels. In addition to protecting metals from oxidation and from harmful effects of hydrogen gas absorption, on some metals vacuum actually is instrumental in breaking down and removing oxide films, resulting in a bright, clean surface. It is often a more economical process than processing with inert gas, when all cost factors are considered.

Vacuum brazing permits an increased latitude in the choice of alloys and results in increased strength and cleaner assemblies. Its main applications are in joining stainless steel parts and components for high temperature applications made from such metals as Inconel, zirconium and titanium alloys.

The availability of high capacity vacuum diffusion pumps makes many vacuum processes practical on a large industrial scale.

New techniques are also being developed in such fields as induction hardening, permitting various shapes to be processed with little or no distortion. Induction tempering continues to attract interest, offering means of selective tempering on a high volume basis and resulting in varying hardnesses and strengths in different zones of the same part.

Adding to the versatility of this method is a large variety of heating units in a wide choice of frequencies, a good selection of control devices, meters, etc., and many specialized work handling units.

There is little doubt that further growth of secondary manufacturing industry in all areas of the country will create new opportunities for business expansion in the metal heat-treating field. At the same time it appears certain that the survival of many of the existing firms largely depends on their ability to acquire the necessary new skills, techniques and facilities which will soon become routine tools of the trade.

PART II

List of Canadian Commercial Heat-Treating Firms

PART II

NAME AND ADDRESS OF FIRM: Aluminum & Steel Heat Treating Limited,
1345 Miron Street,
Montreal 9, P.Q.

INQUIRIES: Mr. W. B. Chadwick,
Manager.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing Stress-relieving	Aluminum alloys	Castings	Shot and sand blasting

PHYSICAL TESTING & QUALITY CONTROL: Equipment available.

COMMENTS:

The company is mainly an aluminum foundry with some fabricating facilities. Up to 80% of heat treating capacity can be available for commercial purposes.

HEAT TREATING FACILITIES

No.	Make of Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
2	Walker Metal Products Furnace KW. 40, DF. 2630	Electric	1600 max.	26" diameter 36" deep	Up to 800 lbs/day	–	Aluminum and bronze castings

NAME AND ADDRESS OF FIRM: B. & W. Heat Treating Limited,
70 Borden Avenue South,
Kitchener, Ontario.

INQUIRIES: Mr. C. R. Beingessner,
President and General Manager.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing (incl. vacuum)	Carbon steels	Small plates, bars & tubing	Vapor degreasing, conventional and caustic washing, shot-blasting, tumbling, vapor suspension blasting (Liquamatte), pickling, oiling, parco-lubrating
Stress-relieving	Alloy steels	Tools and dies	
Normalizing (incl. vacuum)	Stainless steels	Fasteners	
Salt, oil, water or spray quenching	Tool and die steels	Wire products	
Tempering	Aluminum alloys	Castings	Hydraulic straightening presses
Gas, pack and salt carburizing	Copper alloys	Forgings	Deep freeze equipment
Carbonitriding	Titanium alloys	Machine parts & components	
Cyaniding	Zirconium alloys	Mill rolls	
Nitriding		Aircraft parts	
Induction, vacuum and controlled atmosphere brazing			
Induction hardening			
Carbitron hardening			
Vacuum hardening			
Austempering			
Martempering			

PHYSICAL TESTING & QUALITY CONTROL: Complete quality control, including non-destructive and physical testing facilities available. Professional engineering advice and consultation provided.

COMMENTS:

The company is the largest of Canadian commercial heat-treaters with the most complete range of heat-treating facilities. Equipment is available to process most intricate shapes and sizes of tools, dies, machine parts and aircraft components in a wide variety of steel, aluminum, copper, zirconium and other alloys.

Oil quenching facilities include 13 tanks of various dimensions equipped with heat exchangers and circulation pumps for heating and cooling. 12 tanks equipped with agitators and heat exchangers are available for water quenching.

While the average monthly output varies depending on the processing cycles and the product mix, the following estimates have been reported:

Tools and dies	15 tons/month
Machine & Equipment components ...	225 " "
Fasteners	60 " "
Wire products..	40 " "
Castings, forgings, etc.	200 " "
Average total output	540 tons/month

B. & W. Heat Treating Limited,
Kitchener, Ontario.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F. Max.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	Semi Muffle, B. & W.	Oil	1900	36" x 18" x 72"			Open Annealing
1	Semi Muffle, B. & W.	Oil	1900	24" x 20" x 48"			Stress-relieving
1	Semi Muffle, B. & W.	Oil	2400	27" x 24" x 48"			Pack Carburizing
1	Semi Muffle, B. & W.	Oil	1900	28" x 16" x 36"			
1	Muffle Furnace, C.I. Hayes	Electric	1800	18" x 12" x 36"			
1	Homo-Carburizing, G.E.	Electric	1850	18" dia. x 32" deep			Hardening Annealing
1	Homo-Carburizing, L & N	Electric	1850	27" dia. x 42" deep			Carburizing
2	Homo-Draw, L & N	Electric	1250	18" dia. x 36" deep			Stress-relieving
1	Homo-Draw, Birlec	Electric	1300	18" dia. x 12" deep			Tempering
1	Air Draw, B. & W.	Electric	1200	36" x 24" x 72"			
1	Air Draw, B. & W.	Electric	1200	26" x 24" x 72"			Tempering
1	Air Draw, B. & W.	Electric	800	32" x 28" x 56"			Stress-relieving
2	Air Draw, B. & W.	Electric	1200	36" x 36" x 72"			Aluminum alloys
2	Control Atmosphere, Ipsen	Gas	1800	24" x 36" x 16"			Hardening Annealing Carburizing
1	Control Atmosphere, Lindberg	Gas	1800	24" x 36" x 16"			Carbo-Nitriding
1	Control Atmosphere Muffle Furnace, Welmet	Gas	1850	20' x 7' x 6'			Carbo-Nitriding Hardening
1	Gas Nitriding, Birlec	Electric	1000	24" x 13½" x 7"			Nitriding
1	Neutral Salt Pre-heat pot, B. & W.	Gas	1600	16" I.D. x 40" deep			Hardening Annealing
1	Hi-speed Hi-heat, B. & W.	Electric	2350	12" x 15" x 36"			Hardening, Annealing
2	Salt Draw, B. & W.	Gas	1400	16" I.D. x 36" deep			Tempering
1	Hi-speed, Hi-heat Salt, B. & W.	Electric	2400	9" x 11" x 30"			Hardening
1							
1	Salt Draw, Walker	Gas	1100	16" I.D. x 14" deep			Tempering
1	Horizontal Muffle, Volta	Electric	1800	12" x 9" x 30"			Hardening
1	Horizontal Muffle, B. & W.	Electric	1100	12" x 12" x 30"			Tempering
1	Horizontal Muffle, B. & W.	Electric	1200	24" x 18" x 30"			Tempering
1	Vacuum, Ipsen	Electric	2300	22" x 34" x 12"			Hardening, Annealing, Tempering,
1	Nitriding Salt, Apco, B. & W.	Electric	1000	12" I.D. x 24" deep			Nitriding.
1	Circulating Air Draw, Birlec	Electric	700	16" I.D. x 15" deep			Tempering
1	Salt Draw, B. & W.	Electric	1200	34" x 24" x 16"			Tempering
3	Neutral Salt — Apco Neutrachlor, B. & W.	Gas	1600	24" I.D. x 36" deep			Hardening, Normalizing.
1	Salt Draw, B. & W.	Gas	1200	24" I.D. x 36" deep			Tempering
1	Neutral Salt, B. & W.	Electric	1650	24" x 48" x 52"			Hardening, Normalizing
1	Neutral Salt, B. & W.	Gas	1600	16" I.D. x 24" deep			Austempering, Martempering.

B. & W. Heat Treating Limited,
Kitchener, Ontario.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F. max.	Maximum Part Dimensions	Approx. Output.	Type of Controlled Atmosphere	Main Use
1	Cyanide Salt, Apco, B. & W.	Gas	1600	18" x 36" x 24"			Carburizing
2	Cyanide Salt, Apco, B. & W.	Gas	1700	16" I.D. x 24" deep			Carburizing
1	Cyanide Salt, Apco, B. & W.	Gas	1600	18" x 36" x 24"			Carburizing
1	Cyanide Salt, Apco, B. & W.	Electric	1600	18" x 36" x 24"			Carburizing
1	Draw Salt, B. & W.	Electric	1000	18" x 72" x 36"			Tempering
1	Draw Salt, B. & W.	Electric	1000	18" x 60" x 36"			Tempering
1	Draw Salt, B. & W.	Electric	1000	18" x 36" x 36"			Tempering, Mar-quench
1	Draw Salt, B. & W.	Electric	1000	36" x 48" x 52"			Tempering, Mar-quench
1	Draw Salt, B. & W.	Electric	1000	21" x 72" x 36"			Tempering.
1	Induction, Radyne	Electric 50 kw.					Hardening
1	Induction, Radyne	25 kw.					Annealing
1	Induction, Radyne	30 kw.					
1	Induction, Radyne	25 kw.					Brazing
1	Anderson, custom-built	Electric 300 kw.					
1	Controlled Atmosphere, B. & W. Pusher Continuous Carburizer	Gas	1850	18' 8" x 28" x 31"			Carburizing, Annealing, Normalizing
1	Controlled Atmosphere, Ipsen	Gas	1850	24" x 36" x 16"			Carburizing, Hardening Carbo-Nitriding.
1	Car Furnace, B. & W.	Electric	2300	12' x 6' x 6'			Annealing, Normalizing, Precipitation hardening.
1	Oil Draw Apco, B. & W.	Gas	400	15' x 4' x 3'			Tempering
1	Homo-draw, L & N	Electric	1400	14" I.D. x 16-3/4" deep			Tempering, Stress-relieving.
1	Homo-Draw, L & N	Electric	1400	22" I.D. x 20" deep			Tempering,
1	Homo-Draw, L & N	Electric	1400	22" I.D. x 26" deep			Stress-relieving

NAME AND ADDRESS OF FIRM: Canadian Acme Screw & Gear Limited,
207 Weston Road,
Toronto 9, Ontario.

INQUIRIES: Attn: Sales Department

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing	Carbon steels	Tools and dies	Shot cleaning
Stress-relieving	Alloy steels	Machine and equipment components	Shot peening
Normalizing	Stainless steels		Electroplating
Quenching and tempering	Tool and die steels	Fasteners	Grinding
Gas carburizing, nitriding and cyaniding	Copper alloys	Wire Products	Lapping
Flame hardening		Castings	Honing
Induction hardening		Forgings	

PHYSICAL TESTING & QUALITY CONTROL: Facilities available.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	Lindberg	Gas	max. 1800	24" x 48" x 21"	600 lbs/hr	Endothermic	Carbo-nitriding Carburizing Hardening
2	Surface Combustion	Gas	1700	14" x 14" x 12"	1500 lbs/hr	Endothermic	Flame carburizing
1	Belt Furnace Shaker Hearth	Gas	1650	5" length	600 lbs/hr	Endothermic	Hardening
1	Surface Combustion	Gas	1650	6" length	400 lbs/hr	Endothermic	Hardening
1	Tocco 9600 cycle	Induction					Induction hardening
1	Weltronic 450 KC	Induction					Induction hardening
2	Continuous Annealing Furnaces						Cycle annealing of forgings

NAME AND ADDRESS OF FIRM: Canadian General Electric Co. Ltd.,
940 Lansdowne Avenue,
Toronto 4. Ontario.

INQUIRIES: Mr. R. Weichel.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing Stress-relieving	Carbon steels Stainless steels	Castings Forgings	

PHYSICAL TESTING & QUALITY CONTROL: Complete facilities available.

COMMENTS:

The company has an extensive line of other heat-treating equipment for hardening, brazing, annealing and sintering, used exclusively for own production purposes. Equipment listed is available for commercial heat-treating.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	C.G.E.	Electric	Max. 1650	14' x 7' x 7'	160 tons	—	Stress-relieving and annealing

NAME AND ADDRESS OF FIRM: Canadian Heat Treaters Limited,
300 Newkirk Road,
Richmond Hill, Ontario.

INQUIRIES: Mr. J. Garfield Lorriman,
President.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing	Carbon & Alloy steels	Wide plate and sheets	100—ton Pressure
Normalizing	Stainless steels	Castings	Quench with
Stress-relieving	Non-ferrous alloys	Forgings	8000 gal./min.
Water quenching		Bars	water jets, and
Tempering		Shapes	80,000 gal. water
		Tubing	tank

PHYSICAL TESTING & QUALITY CONTROL: Complete quality control service and technical consultation provided.

COMMENTS:

The company produces hardened and tempered alloy steels and abrasion-resistant steels in plates up to 97" wide, 5" thick and 52 ft. long. Several proprietary grades are available in both categories. Sheets, flats, bars and other shapes as well as forgings and castings can be processed. C.H.T. also produces heat treated steel shapes for military purposes, such as armoured vehicles, gun shields, etc.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	Custom built	Gas	max. 1950	97" wide 52 ft. long 20" high	1500 tons/month		Hardening, annealing and normalizing of wide steel plate, forgings and castings.
1	Custom built	Gas	1950	— as above —			Normalizing, tempering and stress-relieving.
1	Custom built	Gas	1950	30" wide 40" long 24" high			Hardening and tempering. Annealing and normalizing.

NAME AND ADDRESS OF FIRM: Canadian Vac-Hyd Processing Limited,
1371 Speers Road,
Oakville, Ontario.

INQUIRIES: Mr. R. E. Pritchard, President. Mr. J. Wright, Vice-President.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing	Carbon steels	Pipe and tubing	Vapor Degreaser
Stress-relieving	Alloy steels	Tools and dies	Glass-bead vapor blast
Normalizing	Stainless steels	Machine & equipment components	Inhibiting oil tank
Quenching and tempering	Tool and die steels	Fasteners	Alkaline cleaners for aluminum and titanium
Gas Nitriding	Aluminum alloys	Wire (in coils)	
Brazing in Endo gas, Hydrogen, Argon and Vacuum	Copper alloys	Castings	Grit blasting
	Titanium alloys	Forginigs	Drilling
Induction hardening	Magnetic annealing of electrical steels	Aircraft components	Grinding
		Jet engine parts	Cutting, etc.
Vacuum heat treating	Sintering of stainless and high alloy powder metal compacts.	Fine precision machined parts.	

PHYSICAL TESTING & QUALITY CONTROL: Hardness testing and metallographic examinations, specialized technical consultation provided.

COMMENTS:

The company serves primarily aircraft and automotive industries, with specialized vacuum and dry hydrogen processing facilities. Vacuum brazing and vacuum heat treating of stainless steels, powder metal parts, high temperature alloys and such non-ferrous metals as zirconium and titanium are some of the areas of specialization. The company has fabrication facilities for production of brazed assemblies, and equipment for spot, metallic arc, inert gas and oxy-acetylene welding.

Canadian Vac-Hyd Processing Ltd.,
Oakville, Ont.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	Retort type Furnace	Electric 30 kw.	Max. 2250	12" dia. x 12" high	25 lbs/hr	Vacuum-hydrogen-argon	Bright annealing and heat treating of air hardenable stainless and tool steels.
1	Retort type Furnace	Electric 30 kw.	2250	16" dia. x 13" high	50 lbs/hr	Hydrogen-argon-nitrogen	
1	Retort type Furnace	Electric 120 kw.	2250 in atmos. 2300 in vacuum	Under atmosphere — 40" dia. x 48" high Vacuum — 30" dia. x 36" high Air — 42" dia. x 62" high	500 lbs/hr	Hydrogen-argon-nitrogen	Hydrogen and vacuum brazing and vacuum annealing. Degassing of titanium and zircaloy.
1	Conveyor belt Furnace	Electric 35 kw.	2050	Belt opening 5" high x 8" wide	300 lbs/hr	Endothermic	Brazing and annealing of carbon and alloy steels. Bright hardening of tool steels.
1	Air circulating Furnace	Electric 12 kw.	1500	Aluminum heat treating 20" dia. x 36" high Gas Nitriding 18" dia. x 32" high	30 lbs/hr	Hydrogen-argon-nitrogen	Aluminum heat treating. Gas Nitriding.
1	Muffle Furnace	Electric 10 kw.	2250	7" wide x 4" high x 11" long	10 lbs/hr	Hydrogen-endo-thermic-argon	Bright annealing, bright hardening, including oil or water quenching.
1	Induction Heater	Electric 30 kw.					Silver brazing and induction hardening.

NAME AND ADDRESS OF FIRM: Colonial Tool Company,
1691 Walker Roal,
Windsor, Ontario.

INQUIRIES: Mr. John B. Lundberg,
Heat Treat Superintendent.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing	Carbon steels	Plates	Sandblasting
Stress-relieving	Alloy steels	Sheets	Grinding
Normalizing	Stainless steels	Bars, angles etc.	Polishing
Quenching and tempering	Tool and die steels	Tools and dies	Machining
Carburizing	Aluminum alloys	Machine and equipment components	Vapor blasting
Nitriding	Copper alloys	Castings	
Cyaniding	Titanium alloys	Forgings	

PHYSICAL TESTING & QUALITY CONTROL: No equipment available.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
4	Upton Salt Baths	Electric	900 to 2350	5" x 60" diameter	Per Month 40,000 lbs.	–	Heat treating of high speed steel
2	Circular Air Draw Furnaces	Gas	1150 max.	28" x 20" x 10'	40,000 lbs.	–	Tempering
1	Salt Nitriding Furnace	Gas	1050 max.	4" x 60"	1,000 lbs.	–	Nitriding
2	Carburizing Furnaces	Gas	1825 max.	30" x 20" x 10'	40,000 lbs.	-	Carburizing and Hardening
2	Carburizing Furnaces	Gas	1825 max.	16" x 10" x 46"	10,000 lbs.	–	Carburizing and Hardening
2	Circular Furnaces	Gas	1450 to 2350	15" dia. x 75"	10,000 lbs.	–	Heat treating of high speed steel

NAME AND ADDRESS OF FIRM: Crucible Steel of Canada Limited,
Sorel, P.Q.

INQUIRIES: Mr. J. L. Gendron,
Sales Department.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing Stress-relieving Normalizing Quenching	Carbon steels Alloy steels Stainless steels Tool and die steels	Bars Plates Tools and dies Forgings Machine components	

PHYSICAL TESTING & QUALITY CONTROL: Complete facilities and technical advice available.

COMMENTS:

The company has facilities for production of alloy and stainless steel ingots up to 48,000 tons per year. A wide range of forged alloy and carbon steel products are produced and equipment for cold finishing of sheets, forging and heat treating is available. Most of the equipment is used for internal processing.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	Johnson Car Type	Gas Fired	2000 max.	Hearth Area 6' x 35' min. to 8'5" x 61'9" max.	1800 tons/ month forged products		Annealing Normalizing Stress-relieving
1	General Electric Pit Type Vertical	Electric	2000 max.	40" diameter 13' to 32' deep	400 tons/ month finished products		Heating for liquid quenching of alloy, stainless and die steels.

NAME AND ADDRESS OF FIRM: Dynamic Industries Inc.,
45 Dorchester Street South,
Quebec 2, P.Q.

INQUIRIES: Mr. J. Vallee,
Contract Manager.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing Stress-relieving Quenching and tempering	Carbon steels Tool and die steels	Tool and dies Machine and equipment components	Sandblasting Pickling Oiling Grinding Polishing Machining

PHYSICAL TESTING & QUALITY CONTROL: Hardness testing.

COMMENTS:

Total output of 1800 lbs. monthly of tools and dies, and 1500 lbs. of machine and equipment components.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	Sentry Model YP4–B	Propane Gas	2500 max.	6" x 6" x 40"		Diamond Block method for H.S. steels.	Hardening of tools, dies and machine components.
1	Wayne Owen Furnace #202	"	1250 to 1800	12" x 6" x 24"			
1	Wayne Lead Cyanide Carburizing Furnace	"	900 to 1700	12" diamenter x 16" deep			
2	Neutral Salt Bath Furnaces #6902	"	900 to 1700	12" diamenter x 16" deep			

NAME AND ADDRESS OF FIRM: Harrington Tool & Die Company Limited,
755 First Avenue,
Lachine, Quebec.

INQUIRIES: Mr. Gordon McNaught,
Vice-President.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing	Carbon steels	Tools and dies	Sandblasting
Normalizing	Alloy steels	Fasteners	Oiling
Stress-relieving	Stainless steels	Wire products	Polishing
Quenching & tempering	Tool & die steels	Machine & equipment components	Machining
Carburizing	Aluminum alloys	Castings	Drilling
Nitriding	Copper alloys		Cutting
Cyaniding			Sub-zero deep freeze (−105° F)
Flame hardening			Vapour degreasing

PHYSICAL TESTING & QUALITY CONTROL: Complete quality control service, including non-destructive testing, and technical consultation provided.

COMMENTS:

The company has extensive machine shop facilities, including boring mills, grinders, drill presses, lathes, shapers etc., in addition to heat treating equipment. Products manufactured include die sets, jigs, fixtures, special machines and equipment components and assemblies. The company does own engineering design and a considerable volume of business comes from custom designing.

The average output is difficult to ascertain due to variations depending on the type of heat treatment and configurations of parts. It has been estimated at 8–10 tons/month.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	Leeds & Northrup Homo furnace	Electric	Max. 1300	14" dia. x 32" deep		A wide choice of atmospheres and salts available.	Equipment used mainly for hardening, carburizing nitriding, cyaniding, annealing, normalizing, etc. of tools, dies and machine parts and components.
1	Vapocarb furnace	Electric	1850	14" dia. x 30" deep			
1	Vapocarb furnace	Electric	1850	8" dia. x 15" deep			
1	High Speed furnace	Electric	2450	6" x 10" x 20" deep			
1	G.E. furnace	Electric	1850	20" x 18" x 40" deep			
1	Ajax Neutral Salt	Electric	1700	9" x 15" x 22" deep			
1	Nitriding pot	Electric	1300	18" dia. x 48" deep			
1	Holden Electric Cyanide bath	Electric	1650	15" x 12" x 15" deep			
1	Nitriding Homo furnace	Electric	1300	27½" dia. x 60" deep			
1	Dr. Schmitz Nitriding	Electric	1300	19" dia. x 50" deep			
1	Heavy Duty Vertical Retort Carburizer	Electric	1850	14" dia. x 30" deep			

NAME AND ADDRESS OF FIRM: Ipsenlab of Canada Limited,
27 Bermondsey Road,
Toronto 16, Ontario.

INQUIRIES: Mr. Charles W. Stokes,
President.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing Stress-relieving Quenching and tempering Gas Carburizing and cyaniding Brazing Industion hardening	Carbon steels Alloy steels Tool & die steels Aluminum alloys Copper alloys Titanium alloys Zirconium	Tools and dies Machine and equipment components Fasteners Wire products Wire in coils Castings Forgings	

PHYSICAL TESTING & QUALITY CONTROL: Complete facilities and technical advice available.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
2	Ipsen	Gas	Max. 1850	18" high x 24" wide x 36" long.	100,000 lbs/month	Endothermic	Production heat treating of tools, dies, forgings, castings, fasteners and machine components.
1	Ipsen Vacuum	Electric	2400	12" high x 24" wide x 36" long	10,000 lbs/month	Vacuum	Production heat treating of tools, dies, brazing
1	Ipsen Vacuum	Electric	2200	12" high x 18" wide x 24" long	7,000 lbs/month	Vacuum	
1	Ipsen Shaker Hearth	Gas	1700		48,000 lbs/month	Endothermic	Production heat treating.
1	Ipsen Tempering	Gas	1000	18" high x 24" wide x 9' long	100,000 lbs/month	None	Tempering, annealing, stress-relieving.

NAME AND ADDRESS OF FIRM: McLeod & Norquay Limited,
2165 West 10th Avenue,
Vancouver 9, B.C.

INQUIRIES: Mr. H. A. Norquay, President, or
Mr. J. P. McCulloch, General Manager.

Heat Treating Processed	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing	Carbon steels	Bars	Pickling
Stress-relieving	Alloy steels	Angles	Soak cleaning
Normalizing	Stainless steels	Machinery shafting	Rust preventative treatment
Quenching and tempering	Tool and die steels	Hollow drill rods	
Salt bath carburizing	Aluminum alloys	Chain saw parts	
Salt bath nitriding	Copper alloys	Tools and dies	
Spin hardening of gears and sprockets.		Machine and equipment components	
		Fasteners	
		Wire Products	
		Castings	
		Forgings	

PHYSICAL TESTING & QUALITY CONTROL: Hardness testing, metallographic examination.

COMMENTS:

Average total monthly output includes 24 tons of tools and dies, 36 tons of machine and equipment components, 8 tons of wire products and 150 tons of fasteners.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	Lindberg Tool Room Cyclone	Electric	Max. 1275	24" x 18" x 15"			Tempering, Stress-relieving
3	Eclipse	Gas	1750	28" long or		Liquid carburizing and neutral salts	Case hardening machinery steels and tool steels
1	Eclipse	Gas	2000	17" diameter			
1	Eclipse	Gas	1750	66" long		Neutral salts	Flat bar stock, shafting.
3	Custom-built Salt Baths	Gas	1650	28" long or 17" diameter		Neutral salts	Bolts, fasteners, etc.
1	Eclipse	Gas	1100	6' long x 2' wide		Salt	Tempering
1	Eclipse	Gas	1100	4' long x 2' wide		Salt	Stress-relieving
2	Custom-built Salt Baths	Gas	700	2' long x 14" deep		Salt	Tempering and Martempering

NAME AND ADDRESS OF FIRM: Metallurgical Services (Toronto) Limited,
54 Brydon Drive,
Rexdale, Ontario.

INQUIRIES: Mr. A. Ironside,
President.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing	Carbon steels	Bars, angles, etc.	Sandblasting
Stress-relieving	Alloy steels	Tools and dies	
Normalizing	Stainless steels	Machine and equipment components	
Quenching and tempering	Tool and die steels	Fasteners	
Gas carburizing, nitriding and cyaniding	Aluminum alloys	Castings	
Flame hardening	Copper alloys Titanium alloys	Forgings	

PHYSICAL TESTING & QUALITY CONTROL: Facilities available.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	Lindberg	Gas	Max. 1850	24" x 36" x 18"	100 tons/month	Endothermic and ammonia	Carbonitriding, Carburizing, Carbon correction, Clean hardening.
1	Stewart Box	Gas	2000	36" x 60" x 20"			Pack carburizing,
1	Stewart Box	Gas	2000	24" x 36" x 24"			Annealing, Stress-
1	Stewart Box	Gas	2000	12" x 18" x 6"			relieving, Normalizing.
1	Cyanide Pot	Gas	1600	18" x 24"	40		Case hardening
1	Neutral Salt Pot	Gas	1600	18" x 24"	40		Tool and die work
1	Neutral Salt Pot	Gas	1600	12" x 18"	10		Tool and die work
1	Marquench	Gas	800	24" x 48"			Tool and die work
1	Salt Tempering	Gas	800	24" x 48"	40		Tool and die work
1	L & N Vapocarb	Electric	1850	16" x 18"	10		Tool and die work
1	Homo Draw	Electric	1250	16" x 18"	10		Tool and die work
1	Cyclone Tempering Furnace	Gas	1400	36" x 48"	40		Production tempering, Solution treatment and aging of aluminum alloys and copper alloys.

NAME AND ADDRESS OF FIRM: The Robert Mitchell Company Limited,
350 Decarie Boulevard,
St. Laurent, Montreal 9, Quebec.

INQUIRIES: Mr. N. J. Watson,
Manager, Foundry Division.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing Stress-relieving Normalizing Water quenching	Aluminum Alloys Copper Alloys Magnesium Alloys	Sand and permanent mould castings	Sand-blasting Pickling Oiling Grinding Polishing Machining Straightening Degreasing Plating

PHYSICAL TESTING & QUALITY CONTROL: Complete quality control facilities including X-Ray equipment. Technical advice and consultation.

COMMENTS:

Maximum monthly capacity approximately 35,000 lbs. Most of the equipment is included in the Foundry Division producing aircraft and missile quality castings as well as sheet metal fabrication.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
3	Walker Metal Products furnaces.	Electrical (air circulated)	1600 max.	38" dia. 30" deep	15,000 lbs/month		Aluminum and Magnesium sand castings for aircraft and commercial use.

NAME AND ADDRESS OF FIRM: Munico Limited,
10,660 Racette Street,
Montreal North, P.Q.

INQUIRIES: Mr. J. Page.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing	Carbon steels	Bars	Shotblasting
Normalizing	Alloy steels	Shapes	Grit blasting
Stress-relieving	Stainless steels	Pipe and tubing	Oiling
Quenching and tempering	Tool and die steels	Tools and dies	
Carburizing	Aluminum alloys	Fasteners	
Nitriding	Copper alloys	Wire Products	
Cyaniding	Titanium alloys	Machine and equipment components	
Brazing		Castings	
Flame hardening		Forgings	

PHYSICAL TESTING & QUALITY CONTROL: Facilities available.

COMMENTS:

Monthly production is approximately 80,000 lbs. of commercial products and another 80,000 lbs. of aircraft materials and parts.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F. Max.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	Birlefco-Lindberg Furnace	Electric	2400	Equipment ranges from 12" diameter 18" deep to 72" diamster 144" deep		Argon gas atmosphere available	Aircraft parts Tools Dies Fasteners Machine parts and components Castings Forgings, etc.
1	Custom-built furnace	Electric	2400				
1	Upton-Lindberg Salt Bath	Electric	2400				
1	Custom-built Salt Bath	Electric	2400				

NAME AND ADDRESS OF FIRM: Preston Heat-Treating Corporation,
753 Bishop Street, Box 176,
Preston, Ontario.

INQUIRIES: Mr. T. Jolley, Sales Manages.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing	Carbon steels	Plates	Sand Blast
Stress-relieving	Alloy steels	Sheets	Vapour Blast
Normalizing	Stainless steels	Bars, angles & other rolled shapes	
Quenching and tempering	Tool & die steels	Pipe & tubing	
Carburizing, nitriding and cyaniding	Aluminum alloys	Tools & dies	
Induction brazing	Copper alloys	Machine and equipment components	
Flame hardening		Fasteners	
Induction hardening		Wire products	
Neutriding		Wire (in coils)	
		Castings	
		Forgings	

PHYSICAL TESTING & QUALITY CONTROL: Quality control facilities available.

COMMENTS:

Extensive facilities and experience available for heat-treating of most shapes in steel, aluminum and copper alloys on production basis.

Preston Heat-Treating Corp.
Preston, Ontario

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	Dow	Gas	Max. 1700	28" x 18" x 12"	20 tons/mth	Endothermic	Carbo-Nitriding.
1	Alicase	Gas	1700	18" x 12" x 18"	40 tons/mth	Endothermic	Commercial.
1	Homo Carb	Electric	1700	30" dia. x 48"	30 tons/mth	Endothermic	Commercial.
1	Continuous Car Furnace		1250	12' wide x 27' long x 7' high			Stress-relieving
1	Upton Salt Bath	Electric	2400	12" x 14" x 20"			High speed salt quech.
1	Upton Salt Bath	Electric	1200				Tool and die production.
1	Ajax Salt Bath	Electric	1600	14" x 22" x 27"			Liquid Carburizing.
1	Ajax Salt Bath	Electric	1650	14" x 22" x 27"			
2	Ajax Salt Baths	Electric	1650	25" x 14" x 18"			Austempering.
1	Ajax Salt Bath	Electric	1000				
1	Tocco Mfg. Induction Unit	Electric 30 Kw. 10 Kcs					Induction hardening and Brazing.
2	Box Open Fire Furnace	Gas	2000	90" x 40" x 24"			Pack Hardening.
1	Box Open Fire Furnace	Gas	1850	36" x 21" x 24"			Annealing & drawing.
1	Lindberg	Electric	1200	16" dia. x 16"			Gas Nitriding.
3	Lindberg	Electric	1200	20" dia. x 20"			Tempering.
2	L. & N.	Electric	1200	36" dia. x 48"			Gas Nitriding, tempering.

NAME AND ADDRESS OF FIRM: Steel Improvement Co. Ltd.,
263–265 Wellington Street West,
Toronto 2B, Ontario.

INQUIRIES: Mr. Victor Spielbergs,
Manager.

Heat Treating Processes	Materials Processad	Shapes Processed	Subsidiary Facilities
Annealing Stress-relieving Normalizing Oil and water quenching Pack or Salt Carburizing and Cyaniding	Carbon steels Alloy steels Stainless steels Tool and die steels Aluminum alloys Copper alloys Titanium alloys Hastalloy	Plates Sheets Bars, angles and other rolled shapes Pipe and tubing Tools and dies Machine and equipment components Fasteners Wire Products Wire (in coils) Castings Forgings	Oil quench tank 2000 gal. 6' x 7' b 8' deep with 500 gal/min. stirring pump. Water quench tank 1500 gal. 7' dia. x 8' deep with recirculating pump. Brine quench tank 3' dia. x 6' deep with recirculating pump.

PHYSICAL TESTING & QUALITY CONTROL: Hardness testing and metallographic examination. Technical advice and consultation on heat treatment. Limited R & D for customers.

COMMENTS:

Monthly output averages 200 tons of annealed and 100 tons of hardened products. In addition, some 10 tons of tools and dies, 5 tons of fasteners, 5 tons of wire products, 60 tons of wire in coils and 80 tons of castings and forgings can be processed.

Specialized experience available in volume production of heavy parts up to 1500 lbs. in ultra high strength steels, wear resistant materials, high temperature alloys and other materials requiring engineering competence and practical ingenuity.

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
1	C.G.E.	Electric 250 kw.	max. 1850	45" x 55" x 13'		—	Annealing. Normalizing.
1	Custom-built	Oil fired	2150	5' x 6' x 2'		—	Stress-relieving. Hardening.
1	Walker metal	Electric 40 kw.	2000	22" x 9" x 6'		—	Tempering.
4	Custom-built Salt Baths	Oil fired	1750	14" dia. x 24" long			Case-hardening tool and die steels and special alloys.
3	Custom-built Salt Baths	Oil fired	1100	20" x 20" x 36"			Tempering and marquenching.
1	Custom-built Degreaser	Oil fired		20" x 20" x 36"			Degreasing.
1	Custom-built Deruster	Oil fired		20" x 20" x 36"			Rust removal.

NAME AND ADDRESS OF FIRM: Waltal Commercial Heat Treating Company,
1520 Notre Dame Street West (Rear),
Montreal, Quebec.

INQUIRIES: Mr. Walter Francoeur.

Heat Treating Processes	Materials Processed	Shapes Processed	Subsidiary Facilities
Annealing	Carbon steels	Tools and dies	
Normalizing	Alloy steels	Machine components	
Quenching and tempering	Stainless steels	Forgings	
Carburizing	Tool and dies		
Cyaniding	Aluminum alloys		

PHYSICAL TESTING & QUALITY CONTROL: Yes

HEAT TREATING FACILITIES

No.	Make or Type	Method of Heating	Operating Temp. °F.	Maximum Part Dimensions	Approx. Output	Type of Controlled Atmosphere	Main Use
2	Batch furnaces	Gas	Max. 1850	18" wide x 32" long x 14" high		–	Annealing, Normalizing,
2	Salt baths	Oil fired	1800	13" dia. 18" deep	200–300 lbs/day	–	Stress-relieving of High speed and
1	High speed furnace	Oil fired	2350			–	tool steels

PART III

HEAT-TREATING TERMINOLOGY

To assist in uniform interpretation of the heat-treating terminology employed with reference to specific metallurgical processes, it was considered desirable to include a section describing commonly used metallurgical terms. Such descriptions are based on the terminology accepted and used by the American Society for Metals Handbook, Vol. 2, which is one of the most authoritative references on heat-treatment. To make this section acceptable to the widest cross-section of possible users, only an essential minimum of specialized metallurgical terms was included.

HEAT-TREATING OF FERROUS METALS

There are several forms of heat-treatment commonly employed in the processing of iron and steel. Each modifies the mechanical properties and structure of steel in its own way and is selected for a specific reason.

Normalizing

Normalizing is a process of heating the steel to approximately 100°F. above the upper critical temperature, followed by cooling in still or agitated air. This treatment refines the structure produced by variations in rolling or forging temperatures and improves its machinability. The highly alloyed steel analyses may require annealing or tempering after normalizing to decrease hardness.

Annealing

This process may involve subcritical heating to relieve stresses and to recrystallize cold worked material, or it may involve heating above the critical temperature with subsequent transformation on cooling. The purposes can be described as softening to improve formability or machinability and stress-relief after cold deformation or after rapid cooling.

Modifications of the annealing process are described by the following terms:

1. *Full-annealing* denotes heating to above the upper critical temperature to obtain full solution of carbides, followed by slow cooling.
2. *Isothermal Annealing* involves heating above transformation temperature followed by transformation to coarse pearlite just below the critical temperature and conventional cooling to room temperature.
3. *Spheroidized Annealing* aims at developing full spheroidization of carbides by long subcritical treatment and very slow cooling.
4. *Process Annealing* involves heating at subcritical temperature to cause recrystallization of the cold worked structure and consequent softening.

Quenching

Rapid cooling of steel from suitable elevated temperature is known as quenching. Its purpose is to develop an acceptable microstructure and mechanical properties which will meet minimum specifications after tempering.

The rate of heat extraction depends on the quenching medium and the method employed. The following terminologies are employed to specifically describe the method used.

1. *Time quenching* describes a process of abruptly changing the cooling rate of the part at some time during the cooling cycle.

2. *Selective quenching* is used when preselected areas of a part are to remain relatively unaffected by the quenching medium.

3. *Spray quenching* denotes directing streams of quenching liquid against local areas or the whole body of the workpiece.

4. *Fog quenching* describes a technique when a fine fog of liquid droplets carried by a gas stream is used as a cooling agent.

5. *Interrupted quenching* pertains to a process of quenching in a molten salt bath at elevated temperature.

Martempering

Also known as marquenching, the process of martempering consists of 1) quenching from austenitizing temperature into molten salt or hot oil medium, 2) holding to achieve temperature equalization, and 3) further cooling, usually in air, at a moderate rate. Martempered parts are subsequently tempered in the usual manner. This technique minimizes residual stresses and distortion resulting from unequal transformation rates typical of conventional quenching.

Austempering

Austempering is a process of isothermal transformation in which the steel is 1) quenched from austenitizing temperature into a bath maintained usually in the range of 500 to 750°F., 2) allowed to transformed completely to bainite, 3) air-cooled to room temperature. The purpose of this technique is to achieve maximum ductility and notch toughness at a given hardness.

Tempering

The purpose of this process is to increase ductility and toughness in a work piece which has been hardened by quenching. The process consists of heating the steel to a temperature below the transformation range, followed by slow cooling.

Carburizing

The process known as carburizing involves imparting a high-carbon surface layer to low-carbon steel which on quenching becomes very hard, while the low carbon core remains comparatively soft and ductile.

Such results can be achieved by the following alternative methods:

1. *Pack carburizing* involves heating the steel in contact with carbonaceous solids.
2. *Gas carburizing* is carried out by heating the steel in an atmosphere of carburizing gases.
3. *Liquid carburizing* depends on immersion of steel in a liquid bath of a suitable carburizing salt.

Nitriding

A case-hardening process, nitriding involves subjecting steel parts to the action of a nitrogenous medium, commonly ammonia gas, at temperatures ranging from approximately 900°F. to 1250°F. The main advantages achieved are wear resistance, retention of hardness at high temperatures and improved corrosion resistance.

Carbonitriding

As the name implies, this is a combined process of absorption of carbon and nitrogen by steels held at elevated temperatures in a gaseous atmosphere containing both elements. The process is also known as dry cyaniding, gas cyaniding or nicarbing.

Cyaniding

Also known as liquid carbonitriding, the process relies on a suitable bath of molten cyanide salt as a source of carbon and nitrogen. Similarly to a gaseous process, the resulting surface of heat-treated steel parts is hard and wear-resistant.

Flame hardening

The process consists of rapid heating of the surface of the hardenable ferrous alloy above the transformation temperature by direct impingement of a high-temperature flame or by high velocity gases, followed by rapid cooling to produce the desired properties.

Flame hardening is usually applied where

1. the dimensions of the part would make other methods of heating uneconomical or impractical,
2. only small segments of a part require heat-treatment,
3. the dimensional accuracy can be better preserved, and
4. flame hardening permits economy in the choice of material.

The principal flame hardening methods are known as stationary, progressive and spinning. Their selection depends on such factors as shape, size and composition of the work piece and the hardening required.

Induction Hardening and Tempering

Induction heating utilizes electromagnetic induction to generate heat for hardening or tempering of iron or steel parts. Specially designed work coils, or inductors, convey alternating current, establishing a highly concentrated, rapidly alternating, magnetic field within such coils. This magnetic field is responsible for heating the part by induction of an electric potential.

Induction heating is fast and economical. Depending on the current frequency used, shallow or deep heat penetration can be achieved. Surface hardening for wear resistance and selective hardening of certain sections of a work piece are some of the most common applications.

Vacuum heat-treating

In the simplest terms, vacuum processes are used to prevent gases from reacting and combining with metals during processing. Vacuum may be considered the ideal inert atmosphere, which is a very valuable factor in protecting metals from oxidation and other undesirable effects of high temperature treatments. The combination of high heat and high vacuum actually decomposes and removes oxide films on some metals, producing a bright surface. Gas absorption, especially harmful in processing active and refractory metals, is eliminated and gaseous impurities are removed. In brazing, vacuum eliminates the need for fluxes and removes the danger of explosions associated with some gases such as hydrogen.

HEAT-TREATING OF NON-FERROUS METALS

ALUMINUM AND ALUMINUM ALLOYS

The main heat-treating processes applied to aluminum alloys are solution treating, quenching, precipitation hardening and annealing.

Solution treating

This treatment takes advantage of the variable solubilities of alloying elements in solid aluminum at different temperatures. The aluminum alloy is soaked at an appropriate temperature to achieve a homogeneous solid solution and then quenched fast to retain the correct structure.

Precipitation hardening

Depending on the alloy composition, the rate of precipitation hardening varies widely. In some alloys sufficient hardening occurs at room temperature over an extended period of time to yield stable products with adequate properties. The objective of precipitation heat-treating is to produce optimum sizes and distribution of precipitate for the best combination of mechanical properties. The process consists essentially of long time, low temperature soaking suitable for the specific alloy.

Annealing

For purposes of removing the effects of work hardening stress-*relief annealing* is employed, consisting of heating to approximately 650°F. or higher, depending on the alloy, and cooling to room temperature. Some soaking may be required to ensure that the proper temperature is reached in all portions of the work piece. Relatively slow cooling in still air or in the furnace is normally employed to minimize distortion and to avoid partial solution treatment.

Full annealing consists of soaking at approximately 775 to 825°F., followed by slow furnace cooling.

COPPER AND COPPER ALLOYS

Homogenizing involves long-term high temperature treatment to minimize segregation in cast structures. Depending on the type of copper alloy, the time and temperature required for diffusion of constituents varies. The primary purpose of this treatment is to increase the strength and ductility before hot or cold working.

Annealing of copper alloys follows a general pattern described for other metals. It involves heating to a temperature necessary to cause recrystallization of cold worked structure. Sometimes higher temperatures are employed to cause grain growth.

Stress-Relieving is generally accomplished by employing the highest stress relief temperature for the shortest time that will not significantly change the mechanical properties. No appreciable decrease in strength or hardness occurs.

Precipitation hardening, also known as aging, is used for such commercial copper alloys as aluminum bronzes, beryllium coppers, copper-nickel-silicon alloys, zirconium copper alloys and others. The process involves rapid cooling from high temperature followed by tempering at lower temperature.

Solution treating is a process similar to that described for aluminum. Age hardenable copper alloys are solution treated at temperatures up to 1900°F. with immediate water quenching. Process characteristics are controlled depending on the alloy composition to produce desired grain size and mechanical properties, and to prevent surface oxidation. Quenching is a critical phase with water being commonly employed as the quenching medium, except in cases where oil or forced air cooling offers the required safeguards against cracking.

MAGNESIUM ALLOYS

Selection of a heat-treatment process for magnesium alloys depends on the composition, form and service requirements. Various modifications of the basic treatments have been developed for specific alloys to obtain the most desirable combination of properties.

Annealing of wrought magnesium alloys is done at temperatures up to 850°F. to facilitate further fabrication. The results are lower tensile properties and improved ductility.

Stress-Relieving reduces residual stresses induced by cold or hot working, shaping or welding. In castings such stresses arise from non-uniform cooling and contraction on solidification.

Solution and precipitation heat-treatments normally employ protective atmospheres of sulfur dioxide or carbon dioxide to prevent surface oxidation and burning at higher temperatures. The time and temperature are predetermined by the alloy's composition and may vary from as low as 300°F to as high as 1000°F., with up to 24 hours at temperature. Quenching of magnesium alloys is generally accomplished by air blast, although in exceptional cases water is used to develop optimum mechanical properties.

NICKEL AND NICKEL ALLOYS

Annealing of nickel alloys to recrystallize work hardened structure requires temperatures between 1300 and 2200°F., with cooling rates depending on the composition and the results required. Precipitation hardening alloys are cooled rapidly to develop maximum softness. Reducing atmospheres and salt bath furnaces are employed to prevent oxidation.

Stress-Relieving is used to reduce stresses in non-age-hardenable alloys without recrystallization. Temperatures in the range of 800 – 1600°F. are used depending on alloy composition and degree of work-hardening.

Stress-Equalizing is another low temperature heat-treatment designed to improve mechanical properties without any detectable microscopic changes. Temperatures between 500 and 900°F. are used with subsequent air cooling The process results in increased hardness, tensile strength and yield strength, better electrical conductivity but no significant change in ductility.

Solution treating, designed to put age-hardening constituents and carbides into solution, is generally performed before aging treatment to enhance special properties. The process consists of soaking at temperatures up to 2100°F., followed by air cooling. Main application of the process is for high temperature nickel alloys requiring maximum creep, relaxation and rupture strength properties.

Precipitation or Age-hardening is performed at intermediate temperatures to develop maximum strength in certain nickel alloys by soaking in the range of 900 to 1600°F., followed by air or furnace cooling. Protective atmospheres are employed for prevention of oxidation.

TITANIUM AND TITANIUM ALLOYS

Stress-Relieving of titanium alloys is similar to that of other non-ferrous metals. Temperatures in the range of 900 to 1300°F. are used depending on the alloy composition, with holding time from 30 minutes to several hours. The time – temperature relationship is chosen to relieve stresses without causing undesirable precipitation or strain aging in alpha-beta and beta-type alloys, and recrystallization in single-phase alloys.

Annealing is designed to develop toughness, ductility at room temperature, improved machinability and structural stability at elevated temperatures. The stabilizing annealing treatment for alpha-beta alloys consists of slow cooling through the transformation range to 1000°F., followed by cooling in air. Other alloys may be air cooled directly from the annealing temperature. A *duplex annealing* procedure involves initial solution annealing of the alloy, air cooling to room temperature, followed by "stabilizing anneal" at temperatures at least 100°F. above the maximum temperature of future application. This process is employed specifically with alloys requiring maximum creep resistance and stability at elevated temperatures.

Solution treating and aging is performed to develop high strength while retaining useful ductility. Commercial titanium alloys are heated in the range of 1400 – 1850°F., followed by rapid water quenching. The alloys are then reheated for several hours in the range of 800 – 1100°F., depending on the alloy and the section thickness to produce high strength together with adequate metallurgical stability.