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"Emerging Technologies of the Steel Industry - New Materials and Steel Product - Mix"

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CONTENTS

Page

Introduction

Based on the deliberations of the technical sessions on Emerging Steel Technologies held during the Materials Week of ASM-International at Cincinnati, Ohio, USA on October 21 - 24, October, 1991, the aim and objectives of this study are to present in a nutshell and outline the current emerging technologies in the iron and steel industry and as a consequence on its product/mix and raw materials development. The applications of the new emerging technologies in the steel industry, both in the developed and the developing countries have gained importance owing to current pattern of global steel growth and market re-orientation.

In recent years some of the emerging steel technologies have taken root and seen industrial scale applications while others proclaimed from the house tops and lauded at international gatherings have dropped out by the wayside. Thus the task of pruning, analyzing, recommending and applying the most optimum technology, particularly for developing countries has not been easy and it has been up to international organizations such as UNIDO to do this search and research and promote the most techno-economical viable technology to the developing countries. These efforts place a high premium on technical and industrial ingenuity. The developed countries have of course, set the pace for the transfer of emerging steel technologies to the developing countries, successfully in the same case and not so successfully in others; the failure and scrapping of the PUROFER Direct Reduction Process Cosigua, in Brazil and its dismantling in the country of its origin itself, i.e., Germany, is an illustration of the latter.

This study is also aligned to the deliberations of the Materials Week of ASM-International particularly its Exhibition of Materials Processes and Material Products held October 21 - 24, 1991; the outline of this Exhibition is added further on in this study.

However, the basic core and theme of this study center around the iron and steel industry, the vast panorama of which presents a challenging spectrum of new and emerging technologies, some proven, others proclaimed so, while some are still in embryonic development stages.

It is difficult in this study to say the last words on the subject; the global steel pattern is today changing fast with the developing world emerging as a major steel producer. UNIDO Lima Declaration of 1975 pointed to the fact that the "Developing Countries" constitute 70% of the world's population and product less than 7% of the world's industrial output. UNIDO Lima Declaration reiterates that the developing countries should remedy this imbalance, by increasing their industrial production to at least 25% of the total world production by the year 2000. It was also pointed out that this share cannot be achieved for every industry. However, some industries were targeted for this optimum percentage; steel was one of them. How far have UNIDO Lima Declaration and Target been achieved for the steel industry? This lends itself to multiple interpretations and conclusions. An attempt will be made here to do so and in such an analysis, let us look at the global steel scenario and part played by the developing countries in its development.

Major steel producing countries from 1981 - 1990 are shown in the following Table 1 (Production in Million Tons).

Table 1

Major Steel-Producing Countries, 1981-1990
(million tons)

***F.G.R. - Prior to Unification**

Country	1981	1983	1986	1989	1990	1990/89 Change
1. USSR	148.5	152.5	160.5	160.1	154.3	-3.6
2. Japan	101.7	97.2	98.3	107.9	110.3	2.2
3. United States	109.6	76.8	74.0	88.8	88.9	0.1
4. China	35.6	39.0	52.2	61.4	67.2	9.4
5. Germany, Fed. Rep.*	41.6	35.7	37.1	41.1	38.4	-6.4
6. Italy	24.8	21.8	23.0	25.2	25.4	0.9
7. Republic of Korea	10.7	11.9	14.5	21.9	23.1	5.7
8. Brazil	13.2	14.7	21.2	25.0	20.6	-17.7
9. France	21.2	17.6	17.7	18.7	19.0	1.7
10. United Kingdom	15.6	15.0	14.8	18.8	17.9	-4.7
World Total	708.4	662.5	713.2	784.3	766.9	-2.2

Table 2 shows the world crude steel production 1981-1990.

TABLE 2

CRUDE STEEL[1]: Production

(thousand tonnes)

Region country or area	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
WORLD	708385	645067	662514	711085	718824	713246	735028	778196	784340	766892
DEVELOPED MARKET ECONOMY COUNTRIES	395568	331373	335719	367234	365036	341782	348881	378365	382817	377045
AMERICA	124433	79529	89593	98659	94724	88133	95643	105555	104330	101038
Canada	14811	11865	12832	14699	14637	14081	14737	14866#	15458#	12100
United States	109613#	67655#	76761#	83940#	80087#	74032#	80876#	90649#	88852#	88918#
EUROPE	152498	137264	135979	148584	149619	139219	139239	151461	153503	149423
EEC	*139862*	*125082*	*123231*	*134482*	*135694*	*125714*	*125958*	*137426*	*139578*	*136470*
Belgium-Luxembourg	16167	13502	13450	15287	14628	13420	13085	14883#	14687#	14953
Denmark	612	560	493	548	528	632	605	650#	624#	609
France	21258	18417	17582	19005	18815	17670	17432	18598#	18692#	19017
Germany, Federal Republic of	41610	35880	35729	39389	40497	37134	36248	41023#	41073#	38434
Greece	909	933	868	972#	1007#	1010	908	959#	956#	986
Ireland	33	61	141	166	203	208	220	271#	324#	326
Italy	24777	24003	21811	24062	23998	22985	22819	23762#	25216#	25439
Netherlands	5472	4354	4477	5738	5519	5283	5082	5518#	5681#	5416
Portugal	555	507	685	697	684	721	732	811#	761#	677
Spain	12896	13160	13009	13497	14193	11882	11691	11886#	12765#	12705
United Kingdom	15573	13705	14986	15121	15722	14769	17136	19065#	18799#	17908
EFTA	*12636*	*12182*	*12748*	*14102*	*13825*	*13505*	*13281*	*14035*	*13925*	*12953*
Austria	4656	4253	4411	4856	4553	4292	4301	4560#	4716#	4291#
Finland	2429	2420	2416	2634	2518	2536	2668	2793#	2921#	2861
Norway	847	768	876	916	944	836	851	910#	678#	376#
Sweden	3770	3900	4210	4706	4813	4716	4595	4779	4692#	4455#
Switzerland	934	836	835	978	967	1075	866	988	916	970
SOUTH AFRICA	8991	8320	7004	7732	8507	9055	8836	8709	9567	8738
ASIA	101790	99637	97252	105676	105381	98385	98629	105780	108009	110451
Israel	114	87	83	92	100	110	116	99	100	120
Japan	101676	99550	97169	105584	105281	98275	98513	105681#	107909#	110331
OCEANIA	7856	6623	5891	6583	6805	6990	6534	6860	7408	7395
Australia	7635	6371#	5657#	6303#	6578#	6703#	6125#	6400#	6800#	6630#
New Zealand	221	252	234	280	227	287	409	460	608	765
DEVELOPING COUNTRIES AND TERRITORIES	65470	67522	71630	79823	86471	91007	98769	109362	114164	112471
AFRICA	2653	2867	3000	2900	3715E	3512	3961	4410E	4130	3005
Algeria	557	868	950	1080	1414	1450	1533	1412	1042	1050
Egypt	1015	1074	979	928	1028	1013	1433	2025	2011	881#
Mauritania	10	10	5	5	2#	5#	7#	5E	5E	5E
Morocco	5	5	4	4	5E	6E	5E	5E	5E	5E
Nigeria	22	90	182	229	321	134#	137#	139#	213#	220
Tunisia	173	107	163	166	160	181	188	162	197	200
Zimbabwe	691	538	547	423	731	674	597	602	592#	579
Other Africa	180	175	70	65	54E	49	61	60E	65	65
AMERICA	27291	27065	28944	33465	36031	37651	39488	42179	42548	38647
Argentina	2526	2900	2942	2647	2939	3242#	3603#	3624#	3893#	3621
Brazil	13226	13000	14671	18395	20454	21228#	22228#	24657#	25017	20582
Chile	644	492	618	692	689	706	720	899	813	773
Colombia	402	422	482	507	530	632	690	712	706	710
Cuba	330	301	354	338	408	411	402	363	432#	340#
Mexico	7605	7060	6917	7482	7299	7225#	7642#	7805#	7870#	8675#
Peru	364	272	299	337	368	358#	400#	463#	397	284
Trinidad and Tobago	45	219	210	172	164	331	388	363	347	380#
Uruguay	14	20	46	41	39	31	30	29	39	30
Venezuela	2030	2278	2320	2770	3055	3402	3297#	3165#	2942#	3177
Other America	105	101	85	94	86	85	88	99	92	75

TABLE 2

CRUDE STEEL[1]: Production
(concluded)

(thousand tonnes)

Region country or area	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
ASIA	31550	33740	35552	39226	42245	45325	50953	58286	62984	67211
Bangladesh	134	78	58	88	122	116	120	120	120E	120E
Hong Kong	80	80	120	120	120F	120E	120E	120E	150E	150E
India	10997	10237	10237	10549	11936	12197	13121	14309	14429	14866
Indonesia	621	693	983	1171	1374	1729	2059	1850	2303#	2600
Iran, Islamic Republic of	565	550	734	854	836	838	839	978	1081	1200
Malaysia	210	215	350	350	400	450	600	700	800	900
Myanmar	45	40	20	20	20E	32#	30E	30E	30E	30E
Pakistan	10	120	300	750	750	900	1000	1200	1200E	1200E
Philippines	400	370	200	250	250	209#	261#	252#	400E	400E
Qatar	469	495	469	478	533	507	492	527	585	571
Republic of Korea	10753	11758	11915	13034	13540	14555	16782	19118	21873	23126
Saudi Arabia	150	150	275	842	1106	1100	1365	1614	1810	1833
Singapore	263	359	305	362	365	390	441	432	495	489
Syrian Arab Republic	400	400	100	100	70E	70E	60E	60E	30#	70#
Taiwan Province of China	3157	4152	5031	5241	5306	5545	5915	8288	9047	9554
Thailand	312	244	381	447	425	450	534	535	550E	600E
Turkey	2425	3183#	3834#	4330#	4662#	5927#	7044#	7983#	7901#	9322#
United Arab Emirates	145	150	50	50	50E	50E	40E	40E	40E	40E
Other Asia	414	466	190	190	180	140	130	130	140	140
EUROPE	3976	3850	4134	4232	4480	4519	4357#	4487#	4502#	3608#
Yugoslavia	3976#	3850#	4134#	4232#	4490#	4519#	4357#	4487#	4502#	3608#
COUNTRIES IN EASTERN EUROPE	206127	203552	210025	214253	214023	221649	224368	224208	219099	203135
Bulgaria	2482	2580	2825	2878	2926	2998	3044	2850	2893	2190#
Czechoslovakia	15271	15000	15024	14831	15036	15112	15416	15379#	15465#	14813
Germany (former German Dem. Rep.)	7467	7250	7219	7573	7840	7967	8243	8133	7829	5587
Hungary	3646	3720	3617	3751	3647	3715	3622	3560#	3305	2362
Poland	15719	14794	16236	16553	16126	17144	17146	16885#	15094	13553
Romania	13025	13055	12593	14437	13795	14276	14962	14314#	14415#	9754#
USSR	148517	147153	152511	154230	154653	160537	161935	163037#	160092#	154286#
SOCIALIST COUNTRIES OF ASIA	41220	42620	45140	49775	53254	58808	63010	66261	68260	74241
China	35600	37000	39040	43475	46794	52208	56280	59431	61430	67241
Democratic People's Republic of Korea	5500	5500	6100	6300	5500	6600	6730	6830	6830	7000
Viet Nam	120	120	-	-	-	-	-	-	-	-

[1] Crude steel: raw form of steel measured at the first stage of solidification, except for liquid steel casting

Table 3 shows the global sponge iron (DRI) production world wide.

TABLE 3

SPONGE IRON (DRI)[1] Production

(thousand tonnes)

Region country or area	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
WORLD	7094	7283	7797	9192	10908	12654	13639	13803	15594	17092
DEVELOPED MARKET ECONOMY COUNTRIES	2270	1183	870	1180	1560	2070	1980	2060	2189	2292
AMERICA	1500	570	540	620	880	850	940	1060	996	1122
Canada	960	500	540	500	740	690	730	770	705	732
United States	540	70	-	120	140	160	210	290	291	390#
EUROPE	490	350	90	120	100	170	200	270	353	310
EEC	*480*	*320*	*70*	*100*	*100*	*170*	*200*	*270*	*353*	*310*
Germany, Federal Republic of	480	320	70	100	100	170	200	270	353	310
EFTA	*10*	*30*	*20*	*20*	-	-	-	-	-	-
Sweden	10	30	20	20	-	-	-	-	-	-
SOUTH AFRICA	120	100	80	270	410	790	840	730	840	860
OCEANIA	160	160	160	170	170	260	-	-	-	-
New Zealand	160	160	160	170	170	260	-	-	-	-
DEVELOPING COUNTRIES AND TERRITORIES	5624	6103	6907	7642	9008	9834	10399	10063	11705	14010
AFRICA	-	80	160	150	220	140	610	902	1040	1331
Egypt	-	-	-	-	-	-	30	470	770	817	710
Libyan Arab Jamahiriya	-	-	-	-	-	-	-	-	90	500
Nigeria	-	80	160	150	220	110	140	132#	133	121
AMERICA	4664	5083	5397	5392	5638	5976	6462	5869	6450	7750
Argentina	830	890	950	910	990	950	1040	1067#	1104	1035
Brazil	230	230	250	250	290	300	200	195#	259	260
Mexico	1720	1510	1500	1450	1454	1370	1560	1617	2237#	2540#
Peru	54#	43#	27#	62#	44#	56#	52#	49#	50	30
Trinidad and Tobabgo	190	240	280	240	220	380	490	593	695	800#
Venezuela	1640	2170	2390	2480	2640	2920	3120	2348#	2044#	3085
ASIA	960	940	1350	2100	3150	3718	3327	3292	4215	4929
India	20	30	40	80	90	148#	177#	195#	360	750
Indonesia	470	440	570	740	1000	1300	1030	980	1210#	1410
Iran, Islamic Republic of	-	-	-	-	30	-	-	-	40	300
Iraq	-	-	-	-	-	-	-	100	200	170
Malaysia	-	-	-	40	520	580	590	427#	644	620
Myanmar	10	10	-	10	30	30	20	20	20	20
Qatar	460	450	390	500	490	490	470	495	534	574
Saudi Arabia	-	10	350	730	990	1170	1040	1075	1207	1085
COUNTRIES IN EASTERN EUROPE	-	-	20	370	420	750	1260	1680	1700	1690
USSR	-	-	20	370	420	750	1260	1680	1700	1690

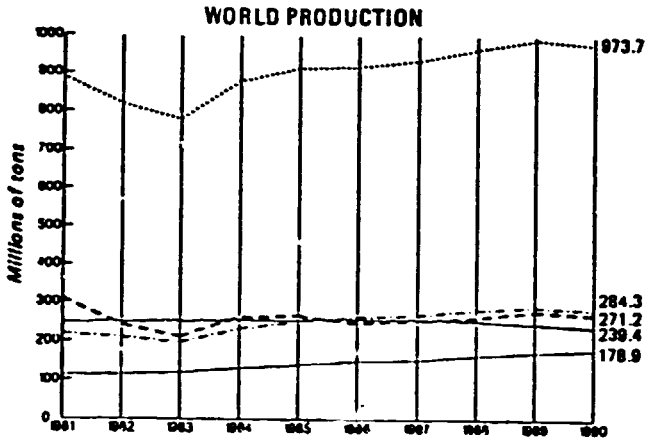
1 Sponge iron or DRI primary iron produced through direct reduction, without exceeding the melting temperature

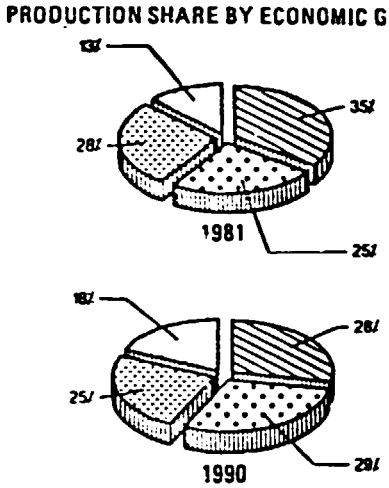
Figure 1 shows the world production of iron ore, pig iron and crude steel.

FIGURE 1

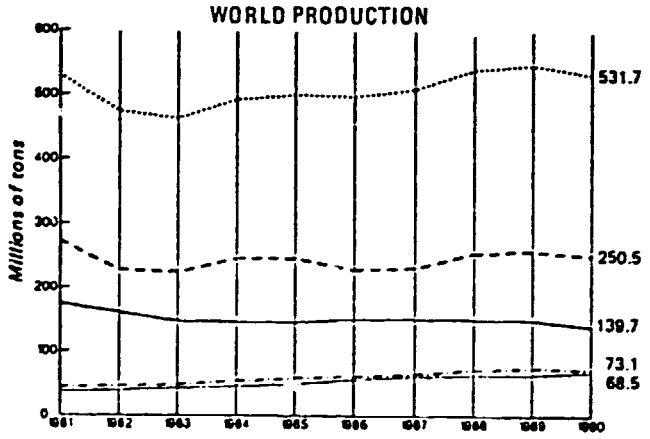
WORLD PRODUCTION OF IRON ORE, PIG IRON AND CRUDE STEEL

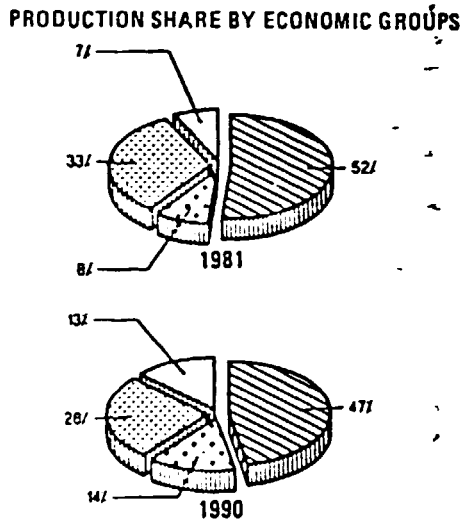
IRON ORE



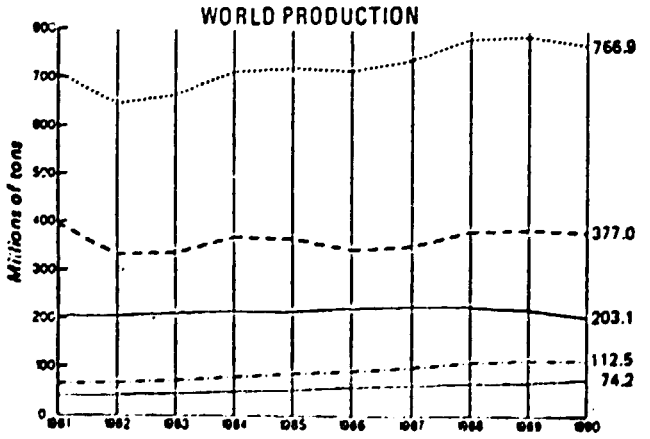


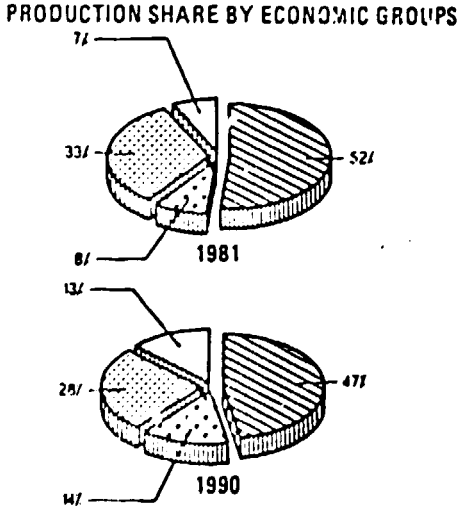
PIG IRON





CRUDE STEEL





World
Developed Market-Economy Countries
Developing Countries
Countries of Eastern Europe
Socialist Countries of Asia

Developed Market-Economy Countries
Developing Countries
Countries of Eastern Europe
Socialist Countries of Asia

Table 4 shows the growth of steel production in developing countries, from 1983-1990 and depicts the share of developing countries including China and other Asian CPEs to be 22.8% in 1990. In some quarter such as the International Iron and Steel Institute, China and Asian CPE countries are not grouped amongst Developing Countries; however, it is a matter of opinion and interpretation - the statistics speak for themselves.

Table 4

Share of Developing Countries in Global Steel Production

	1990	1989	1988	1987	1986	1985	1984	1983	88/90 Change %
Industrial Cts	**389.6**	**395.4**	**391.2**	**360.8**	**352.1**	**374.3**	**375.6**	**343.8**	**-1.5**
E.C.(12)	136.5	140.1	137.8	126.5	125.9	135.7	134.4	123.2	-2.6
United States	88.7	88.9	90.7	80.9	74.0	80.1	83.9	76.8	-0.2
Japan	110.3	107.9	105.7	98.5	98.3	105.3	105.6	97.2	2.2
Developing Cts	**101.2**	**101.9**	**97.6**	**87.8**	**80.6**	**76.9**	**70.1**	**63.1**	**-0.7**
Western World	**490.8**	**497.3**	**488.8**	**448.6**	**432.7**	**451.2**	**445.7**	**406.9**	**-0.7**
USSR & Other CMEA*	204.6	219.6	224.6	224.8	222.2	214.6	214.7	210.5	-6.8
Asian CPEs§	74.2	6.83	66.0	62.8	58.8	53.3	50.0	46.1	8.8
Total CPEs	**278.9**	**287.8**	**290.6**	**287.6**	**281.0**	**267.8**	**264.6**	**256.6**	**-3.1**
World Total	**769.6**	**785.1**	**779.4**	**736.2**	**713.7**	**719.9**	**710.4**	**663.5**	**-2.0**
Developing Countries, China & Other Asian CPEs as percentage of world total (%)	**22.8**	**21.7**	**21.0**	**20.4**	**19.5**	**18.1**	**16.9**	**16.5**	**5.0**

* Council for Mutual Economic Assistance
§ Centrally Planned Economics

In 1990 world demand for steel was less buoyant than in 1989, but remained relatively high. Worldwide crude steel output declined to 767 million tons, 2.2 percent below the preceding year. The weakening of the steel market largely reflected the sharp contraction of steel consumption and production in Latin America (-9%), as well as in the Soviet Union and Eastern Europe as a whole (-7%). In contrast, the expansion of steel production in Asia continued, with remarkable increases in China, the Republic of Korea and Japan.

Almost 50% of the world steel output is produced in developed market-economy countries, where total production reached 390 million tons in 1990, 1.5% below 1989. This slight decline resulted from the deceleration of economic growth in industrialized countries and consequent automotive industry and construction. In Japan, the largest iron ore importer, crude steel production in 1990 increased for the fourth consecutive year, exceeding 110 million tons (+ 2.2%), the highest level for the last decade. The Japanese economy was positively influenced by the high level of domestic steel demand, sustained the dynamism of the building and industrial machinery sectors, which both increased by more than 10%, followed by a 5% increase in the automotive industry.

Table 5 depicts the major steel producing countries, 1989 and 1990.

TABLE 5

The Major Steel-Producing Countries, 1989 and 1990

million metric tons crude steel production

Country	1990		1989	
	Rank	Tonnage	Rank	Tonnage
USSR	1	154.4	1	160.1
Japan	2	110.3	2	107.9
United States	3	88.9	3	88.8
PR China	4	67.2	4	61.6
FR Germany	5	38.4	5	41.1
Italy	6	25.5	6	25.2
Republic of Korea	7	23.1	8	21.9
Brazil	8	20.6	7	25.1
France	9	19.0	10	18.7
United Kingdom	10	17.8	9	18.7
India	11	15.0	14	14.6
Czechoslovakia	12	14.9	11	15.5
Poland	13	13.6	13	15.1
Spain	14	12.9	16	12.8
Canada	15	12.3	12	15.5
Belgium	16	11.4	17	10.9
Taiwan (ROC)	17	9.7	19	9.0
Romania	18	9.7	15	14.4
Turkey	19	9.3	22	7.8
Mexico	20	8.7	20	7.9
South Africa	21	8.6	18	9.3
DPR Korea (E)	22	7.0	23	6.9
Australia	23	6.7	24	6.7
German Dem. Rep.	24	5.6	21	7.8
Netherlands	25	5.4	25	5.7
Sweden	26	4.5	27	4.7
Austria	27	4.3	26	4.7
Argentina	28	3.6	29	3.9
Yugoslavia	29	3.6	28	4.4
Luxembourg	30	3.6	30	3.7
Venezuela	31	3.2	32	3.2
Hungary	32	2.9	31	3.6
Finland	33	2.9	33	2.9
Indonesia (E)	34	2.6	35	2.4
Bulgaria	35	2.4	34	2.9
Egypt	36	2.1	36	2.1
Other Countries		18.4		17.9
World Total		**770.1**		**785.5**

This table lists all countries producing more than two million metric tons of crude steel in either year shown.

Table 6 shows the largest steel producing companies in the western world.

TABLE 6

The Largest Steel-Producing Companies, 1989 and 1990

million metric tons crude steel output

1990		1989			1990		1989		
1	28.8	1	28.4	Nippon Steel	31	3.6	31	3.7	ARBED
2	23.3	2	23.0	USINOR SACILOR *	32	3.5	36	3.4	Tokyo Steel
3	16.2	3	15.5	POSCO	33	3.5	25	4.4	USIMINAS
4	13.8	4	14.2	British Steel	34	3.4	54	2.3	Nucor
5	12.4	5	12.9	USX	35	3.4	32	3.6	Klöckner-Werke
6	12.1	6	12.3	NKK	36	3.1	42	2.8	Saarstahl
7	11.5	8	11.4	ILVA	37	3.1	41	2.9	AHMSA
8	11.1	7	11.6	Thyssen	38	3.0	33	3.6	Mannesmann
9	11.1	11	11.0	Sumitomo	39	2.9	34	3.5	CSN
10	11.1	10	11.0	Kawasaki	40	2.8	46	2.6	SSAB Svenskt Stål
11	9.9	9	11.1	Bethlehem Steel	41	2.7	40	2.9	SIDOR
12	8.8	12	8.5	SAIL	42	2.6	39	3.1	COSIPA
13	7.4	13	7.7	LTV	43	2.5	49	2.4	North Star
14	6.6	15	6.5	Kobe Steel	44	2.5	27	4.3	Stelco
15	6.3	14	7.0	ISCOR	45	2.5	44	2.6	Rouge Steel
16	6.1	16	6.3	BHP	46	2.4	53	2.3	Turkish Iron and Steel Works
17	5.6	17	6.0	China Steel	47	2.4	48	2.4	Gerdau
18	5.2	21	4.9	National Steel	48	2.4	51	2.3	Toa
19	5.2	18	5.4	Hoogovens	49	2.4	47	2.4	Rautaruukki Oy
20	4.8	19	5.0	Inland Steel	50	2.3	43	2.7	Weirton
21	4.8	20	5.0	Armco	51	2.3	50	2.3	TISCO
22	4.3	26	4.4	Cockerill-Sambre	52	2.3	55	2.3	Wheeling-Pittsburgh
23	4.3	22	4.6	Krupp Stahl	53	2.2	56	2.2	Nakayama Steel
24	4.2	24	4.4	Preussag **	54	2.2	60	1.9	AÇOMINAS
25	4.1	28	4.1	Hoesch	55	2.0	37	3.3	CST
26	4.1	23	4.5	Voest-Alpine Stahl	56	2.0	58	2.1	SOMISA
27	4.0	30	4.0	ENSIDESA	57	2.0	59	2.0	Daido Steel
28	3.8	38	3.3	SIDMAR	58	1.9	57	2.1	Co-Steel
29	3.8	29	4.0	Dofasco	59	1.9	52	2.3	United Engineering Steels
30	3.6	35	3.4	Nisshin Steel	60	1.8	61	1.8	Godo Steel

* 1989 figure includes output of plants in FR Germany
1990 figure includes output of plants in FR Germany and the United States

** formerly Peine-Salzgitter

Table 7 shows the crude steel production by different processes.

TABLE 7

Crude Steel Production by Process, 1990

	Production million metric tons	Oxygen %	Electric %	Open Hearth %	Other %	Total %
Belgium	11.4	90.9	9.1	-	-	100.0
Denmark	0.6	-	100.0	-	-	100.0
France	19.0	71.6	28.4	-	-	100.0
FR Germany	38.4	81.5	18.5	-	-	100.0
Greece	1.1	-	100.0	-	-	100.0
Ireland	0.3	-	100.0	-	-	100.0
Italy	25.5	43.9	56.1	-	-	100.0
Luxembourg	3.6	100.0	-	-	-	100.0
Netherlands	5.4	95.7	4.3	-	-	100.0
Portugal	0.7	47.9	52.1	-	-	100.0
Spain	12.9	43.2	56.8	-	-	100.0
United Kingdom	17.8	73.8	26.2	-	-	100.0
EC Total	136.8	69.0	31.0	-	-	100.0
Austria	4.3	91.4	8.6	-	-	100.0
Finland	2.9	84.1	15.9	-	-	100.0
Norway	0.4	-	100.0	-	-	100.0
Sweden	4.5	60.9	39.1	-	-	100.0
Turkey	9.3	40.4	53.2	6.5	-	100.0
Yugoslavia	3.6	47.5	30.5	22.0	-	100.0
Other W. Europe	24.9	58.2	36.1	5.6	-	100.0
Total W. Europe	161.7	67.3	31.8	0.9	-	100.0
Canada (1)	12.3	63.3	36.7	-	-	100.0
United States	88.9	59.6	36.8	3.6	-	100.0
Japan	110.3	68.6	31.4	-	-	100.0
Australia	6.7	92.0	8.0	-	-	100.0
New Zealand	0.8	62.7	37.3	-	-	100.0
South Africa	8.6	63.5	35.2	-	1.3	100.0
Total Industrial Cts.	389.3	66.1	32.7	1.2	0.0	100.0
Argentina	3.6	54.6	44.6	0.8	-	100.0
Brazil	20.6	74.0	23.8	-	2.2	100.0
Chile	0.8	94.3	5.7	-	-	100.0
Mexico	8.7	40.8	51.1	8.1	-	100.0
Peru	0.3	37.2	62.8	-	-	100.0
Venezuela	3.2	0.0	90.6	9.4	-	100.0
India	15.0	41.3	27.5	31.3	-	100.0
Republic of Korea	23.1	68.9	31.1	-	-	100.0
Taiwan (ROC)	9.7	57.7	41.5	-	0.8	100.0
Total Western Cts.*	474.2	64.7	33.0	2.2	0.1	100.0
Bulgaria (E)	2.4	50.0	40.0	10.0	-	100.0
Czechoslovakia	14.9	47.7	13.2	39.1	-	100.0
German DR (E)	5.6	34.3	31.4	34.0	0.3	100.0
Hungary	2.8	50.7	7.1	42.2	-	100.0
Poland	13.6	52.9	18.0	29.1	0.0	100.0
Romania (E)	9.7	54.4	23.9	21.7	-	100.0
USSR	154.4	35.2	13.0	51.7	0.0	100.0
Tot. Eastern Europe	203.4	38.6	14.7	46.7	0.0	100.0
Total**	677.6	56.8	27.5	15.5	0.1	100.0

(1) Oxygen figure includes Open Hearth.
*-The countries included account for 96 per cent of total Western World output.
**-The countries included account for 88 per cent of total World output.

Table 8 shows the continuously cast steel output and its ratio to crude steel output - worldwide.

TABLE 8

Continuously-Cast Steel Output, 1988 to 1990

	million metric tons			% crude steel output		
	1988	1989	1990	1988	1989	1990
Belgium	9.9	10.0	10.5	88.0	90.9	91.7
Denmark	0.7	0.6	0.6	100.0	100.0	100.0
France	18.0	17.5	17.9	94.0	93.7	94.3
FR Germany	36.3	36.9	35.1	88.5	89.8	91.3
Ireland	0.3	0.3	0.3	100.0	100.0	100.0
Italy	22.1	23.7	24.2	92.9	94.1	94.8
Luxembourg	1.3	1.2	1.2	34.2	33.5	34.1
Netherlands	4.2	4.9	5.1	75.6	87.1	93.5
Portugal	0.4	0.4	0.4	46.9	51.4	54.6
Spain	8.8	11.0	11.5	74.4	86.0	89.0
United Kingdom	13.4	15.0	14.9	70.5	80.2	83.6
EC (11)	115.2	121.6	121.7	84.1	87.8	89.6
Austria	4.4	4.5	4.1	95.5	95.7	95.9
Finland	2.6	2.7	2.8	93.9	94.0	97.8
Norway	0.5	0.4	0.4	53.4	60.3	92.7
Sweden	4.0	3.9	3.8	83.0	82.3	85.8
Turkey	6.8	6.4	7.7	84.6	82.3	82 2
Yugoslavia	2.8	2.9	2.5	61.9	64.7	70 2
Other West. Europe	21.0	20.8	21.3	82.2	82.5	85.4
Total West. Europe	136.1	142.4	142.9	83.8	87.0	89.0
Canada	10.3	11.8	9.4	69.3	76.1	76.7
United States	55.5	57.6	59.6	61.3	64.8	67.1
Japan	98.4	100.9	103.7	93.1	93.5	93 9
Australia	4.6	5.4	5.4	71.5	80.0	81 5
South Africa	6.2	6.9	6.4	69.6	73.4	73 7
Total Industrial Cts.	311.1	324.8	327.4	80.0	82.9	84.9
Argentina	2.5	2.9	2.7	68.2	73.2	74 3
Brazil	12.1	13.5	12.0	49.0	53.9	58 5
Chile	0.0	0.0	0.0	1.7	2.0	2 2
Mexico	4.3	4.6	5.3	55.9	58.1	61 2
Venezuela	2.9	2.5	2.0	78.7	78.3	64 0
Republic of Korea	16.9	20.6	22.2	88.3	94.1	96 1
Taiwan (ROC)	7.8	8.4	9.4	93.6	93.1	96 1
Qatar	0.5	0.6	0.6	100.0	100.0	100 0
Total Western Cts.*	358.0	377.9	385.7	78.2	81.2	84.1
Bulgaria (E: 1990)	0.4	0.5	0.4	15.5	15.5	15 4
Czechoslovakia	1.3	1.4	1.7	8.7	9.2	11 5
German DR (E: 1990)	3.2	3.2	2.3	39.6	41.0	41 1
Hungary	2.3	1.8	1.8	63.2	51.4	64 2
Poland	1.9	1.2	1.0	11.1	7.7	7 0
Romania	4.5	4.9	3.5	31.5	34.2	36 5
USSR	27.1	27.6	27.7	16.6	17.3	17 9
Total East. Europe	40.7	40.6	38.4	18.2	18.5	18.8
Total **	398.7	418.5	424.1	58.5	61.1	64 0

* The countries included account for 96 per cent of total Western World output
**The countries included account for 88 per cent of total World output.

In 1982, it took 10.59 manhours to produce a metric ton of steel in the USA while the Japanese took 10.1 manhours. Today the USA manhours per ton of steel have dropped to 5.4 manhours/ton of steel compared to 5.6 manhours/ton. of steel made in Japan. These manhours are further dropping appreciably to produce a ton of steel.

Figure 2 shows the capital investment expenditure by the iron and steel industry in various countries.

FIGURE 2

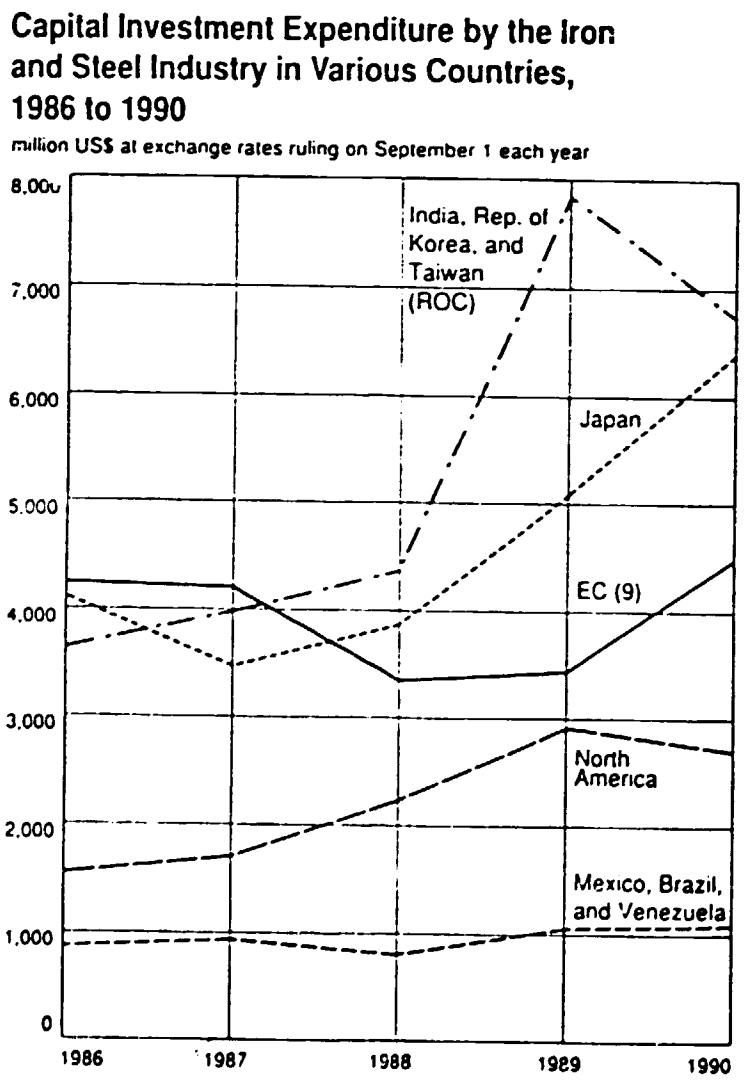


Table 9 depicts the steel production of different country during the first 6 months of 1991.

TABLE 9

Raw Steel Output

('000 tonnes)

	Jun-91	January - June 1990	1991	% change
Belgium	966	5,942	5,960	+0.3
Denmark	63	305	359	+17.7
France	1,723	9,983	9,860	-12
West Germany	3,361	19,388	19,898	+2.6
Greece	80	532	516	-3.0
Ireland	25	170	157	-7.6
Italy	2,087	13,538	12,995	-4.0
Luxembourg	299	1,783	1,672	-6.2
Netherlands	417	2,684	2,459	-8.4
Portugal	51	382	241	-36.9
Spain	1,050	6,526	6,415	-1.7
United Kingdom	1,444	9,338	8,405	-10.0
EC Total	11,566	70,572	68,937	-2.3
Austria	359	2,218	2,163	-2.5
Finland	222	1,456	1,473	+0.5
Norway	45	185	224	+21.0
Sweden	344	2,447	2,288	-6.5
Turkey	784	4,620	4,541	-1.7
Yugoslavia	180*	1,944	1,248	-35.8
Canada	1,085	7,355	6,560	-10.8
United States	6,147	44,676	38,457	-13.9
Argentina	235*	1,730	1,449	-16.3
Brazil	1,705	10,121	10,957	+8.3
Chile	80*	331	444	+33.9
Mexico	665*	4,299	4,280	-0.4
Venezuela	270*	1,611	1,555	-3.5
Qatar	50*	278	282	+1.6
Saudi Arabia	164	666	951	+9.8
India	1,289	7,440	8,026	+7.9
Taiwan	730*	4,592	4,876	+6.2
South Korea	2,163	11,344	12,855	+13.3
Japan	9,332	54,058	56,453	+4.4
Australia	460	3,182	2,735	+14.0
South Africa	840	4,255	4,755	+11.7
Nigeria	15	104	60	-42.5
Zimbabwe	54	298	238	-20.2
Total 35 countries	38,784	239,992	235,808	-1.7
Czechoslovakia	1,100*	7,627	6,398	-1.7
East Germany	313	3,604	1,805	49.9
Hungary	190*	1,501	1,208	-19.5
Poland	910*	7,047	5,998	-14.9
U.S.S.R.	12,000*	79,162	70,755	-10.6
China	5,610*	32,298	33,649	+4.2
Total 41 countries	58,907	371,231	356,221	-4.0

[US]

Labor productivity measured in terms of tonnes of steel produced per man year has been reported in 1989 to be the highest for Pohang (South Korea) at 612 tonnes, NSC-Japan at 392 tonnes, Kawasaki-Japan at 352 tonnes, Usiminas Brazil at 109 tonnes, etc. These figures are being continuously upgraded in the developed and developing countries alike.

Current Status and Commercial Potentials of Smelt-Reduction Technologies

In reviewing the current status and commercial potentials of smelt-reduction technologies, one has perforce to identify and outline the main basis and reasons which led to their development in the first place and present thereafter how far such developments and newer processes have technologically been successful and commercially remunerative/acceptable. Proclaiming a new technological process or process route in itself is the background,of a plethora of such processes mushrooming over the globe, can substantively mean or contribute very little in the long run. One has to look for and analyze the reasons/origin of the new processes/technologies before proceeding further.

One of the main reasons/causes which has led to a train of newer processes involving smelt reduction technologies, proven or still embryonic, is the "coke" for operating the iron blast furnace and the metallurgical grades of coking coals needed to produce blast furnace coke in the literally high/tall coke ovens and the high capital costs required to build them. Add to these capital costs, the costs of applying environmental pollution control measures to a capital intensive coke oven battery, and the story is complete to develop smelt reduction technologies based on non-coking coals to produce iron and steel from iron ores. The current capital costs of building a new coke oven battery at a green field site or of a brown field installation, could be in the range of 300-400 US$ per annual ton capacity depending upon the extend of raw material's costs and the costs of auxiliary materials handling, by-product's recovery and environmental control mandatory provisions.

Such a new coke oven battery would need about 100 US$ to operate it and about 70-85 US$ per annual ton for financial charges, and the coke would base to sell at 140-150 US$ per ton to reach the break-even point.

From the existing/operating coke ovens, in the early part of 1989, the FOB market coke prices have ranged up to 125 US$ per ton and for spot market overseas coke prices have ranged up to 135 US$ per ton at the loading point excluding the freight and transport charges for the escalating CIF prices. With such a "coke" scenario, the race to develop technologies to do away with the metallurgical coke, was on, hurtling one process after another in rapid succession based on smelt-reduction technologies using non-coking coals, with each newer process proclaiming to be the winner. The resulting succession and procession of smelt-reduction processes/technologies have yet to fully establish their industrial acceptance for commercial scale operations. Other hybrid processes based on steel scrap with or without the use of electric power using coal, oxygen, oil and hydrocarbon gases are achieving significant industrial scale applications. Pulverized coal injection to the iron blast furnace has also gained considerable success and commercial acceptance. Meanwhile, concentrated efforts are being made worldwide to develop direct steel making including the USA where AISI has initiated cooperative efforts to develop direct steel making. [1]

In the case of mini steel plants based on electric arc furnaces, with the applications of new technologies such as scrap preheating, water cooled panels, eccentric bottom tapping, oxyfuel burners, ladle refining and computerized process control, etc., the electric arc furnace capacity could be increased substantially and power consumption reduced equally without increases in installed

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1 W.A. Tony - AISI Proceeds with Direct Steel Making Plan, Iron and Steel Maker, June 1989 - pp. 21-22

transformer capacity. Badische-Stahlwerke (BSW) recently estimated that electric arc furnace operations could achieve a production cost savings of up to 30 US$ per ton by following BSW practice/technology.[1]

It is also fully possible that the applications of thin slab casting CSP - compact strip production by Schloemann-Siemag and advancement in rolling operations mill permit mini steel plants to diversify into flat products.

In the background of these success stories of mini steel plants, let us see how far the smelt-reduction technologies have developed to date to obtain hot metal (liquid iron) directly from iron ores and non-coking coals as also other hybrid technologies to obtain liquid steel from hot metal and scrap charges in various proportions - EOF, KMS and KS processes, etc.

The increasing applications of submerged arc electric furnace smelting operations in open slag baths in rectangular furnaces with six electrodes coupled with ladle metallurgy deserve full attention.

This then is the background and introduction to this study which deals with complex and controversial subjects with the hope of not being misunderstood at the same time.

In doing so, no attempt will again be made to list all the smelt reduction processes that have been announced so far in having developed from laboratory to pilot plant scale and possibly attempted on industrial scale operations; these have been listed at many international conferences/seminars without in most cases providing full clues as to their industrial scale success and applications.

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[1] K. H. Klein and G. Paul, "Reflections on the possibility and limitations of cost savings in electric arc furnace steel production" - Iron and Steel Maker, January 1989 - pp. 25-34.

Current Status of Smelt-Reduction Technologies

It will neither be possible nor desirable to discuss each and every newly announced process; the lists are formidable and so is the task of doing so. Some of the newly announced processes are no longer heard of or reported upon in terms of their further progress to date even by the sponsors of the processes themselves; processes such as the ELRED, INRED fall into the latter categories without any industrial plant set up therefor.

The analyses of such newly emerging technologies[1,2] were furnished by the writer in earlier symposia and conferences. Supplementary to these presentations, a most recent[3] development relates to the British Steel and Hoogovens collaborating in a development in which the blast furnace is literally split. The hearth of the blast furnace becomes a two chamber melting pot, wherein partly reduced iron ore and coal are reacted with oxygen injected from a top lance. The molten metal flows over into a second chamber and is tapped intermittently using conventional blast furnace technology. Gases from the melting chambers are cleaned and cooled to a temperature suitable for injection into the top part of the hearth where direct reduction of the iron ore takes place. The cost comparison of the CBF (converted blast furnace) of the natural blast furnace is furnished in Table 10.

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1 Techno-Economic Considerations for Establishment of Steel Industry Based on Direct Reduction Technology for Stronger Production by B. R. Nijhawan, UN - ECE - Seminar, Amsterdam, May 1983.

2 Direct Reduction Processes for Sponge Production Economics and Technology by B. R. Nijhawan, AISU - Symposium, September 1984.

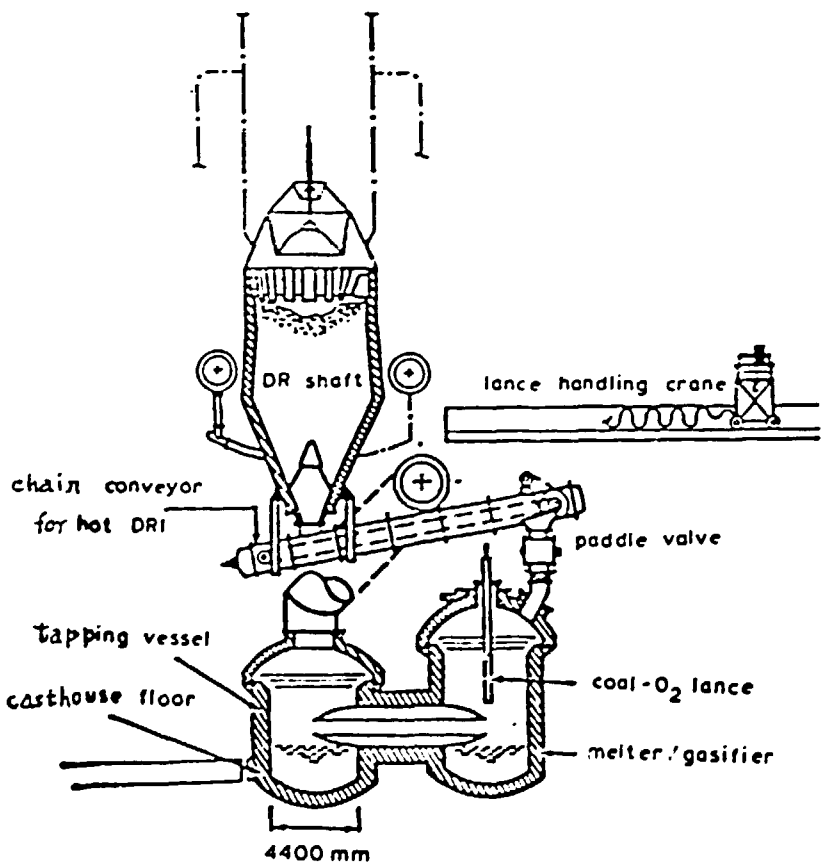
3 Developments in British Steel, Dr. R. Baker, Ironmaking and Steelmaking IIM - UK, 1989 - Vol. 16, No. 3, pp. 145-149.

Table 10

Cost Comparisons - £s/ton of hot metal

Item	CBF	BF
Hot Metal	45	48
Desulphurised Hot Metal	48.5	50
Liquid Steel Cost	57	60
Capital Charges	29	37
Maintenance Costs	13	18
Overall Cost of Liquid Steel	99	115

Figure 3 shows Hoogovens No. 3 Blast Furnace Conversion to CBF



Hoogovens no. 3 blast furnace conversion to CBF

Smelt reduction processes of Kawasaki, Krupp Coin, etc. have also not been reported in terms of their industrial scale applications/installations in recent years.

Concerning the Corex process, the industrial plant/project of Wierton in United States has been cancelled a couple of years back while the industrial scale results at ISCOR's Pretoria works in South Africa have recently been summed up in the latest paper[1] presented during the AISE 1990 Annual Convention, October 90 vide the conclusions quoted herewith from this paper.

The Corex technology has proven its commercial maturity in an industrial sized plant.

For this 300,000 ton/year hot metal plant, a contract was signed in April 1985 between ISCOR, South Africa, and the consortium Deutsche Voest-Alpine/Voest Alpine.

After the initial operating campaign from August 1988 to February 1989, and the following period of debugging, the plant was restarted on November 10, 1989. Within four weeks, the plant was brought up to full capacity and based on excellent availability, considerably higher than 90%, very good metallurgical results have been achieved. Based on a 100% non-coking coal mix, the hot metal had the usual blast furnace quality. With a 100% pellet feed, the production could be increased by 20 to 25% vs. 100% lump ore feed.

Consequently, on December 23, 1989, ISCOR officially took over the plant and integrated it into its production line of Pretoria works.

<u>The EOF - Energy Optimizing Furnace</u>

The Energy Optimizing Furnace (EOF) has been developed at the Companhia Siderurgica PAINS located in Divinpolis, a town in the State of Mines Gerais in Brazil. The main features of the

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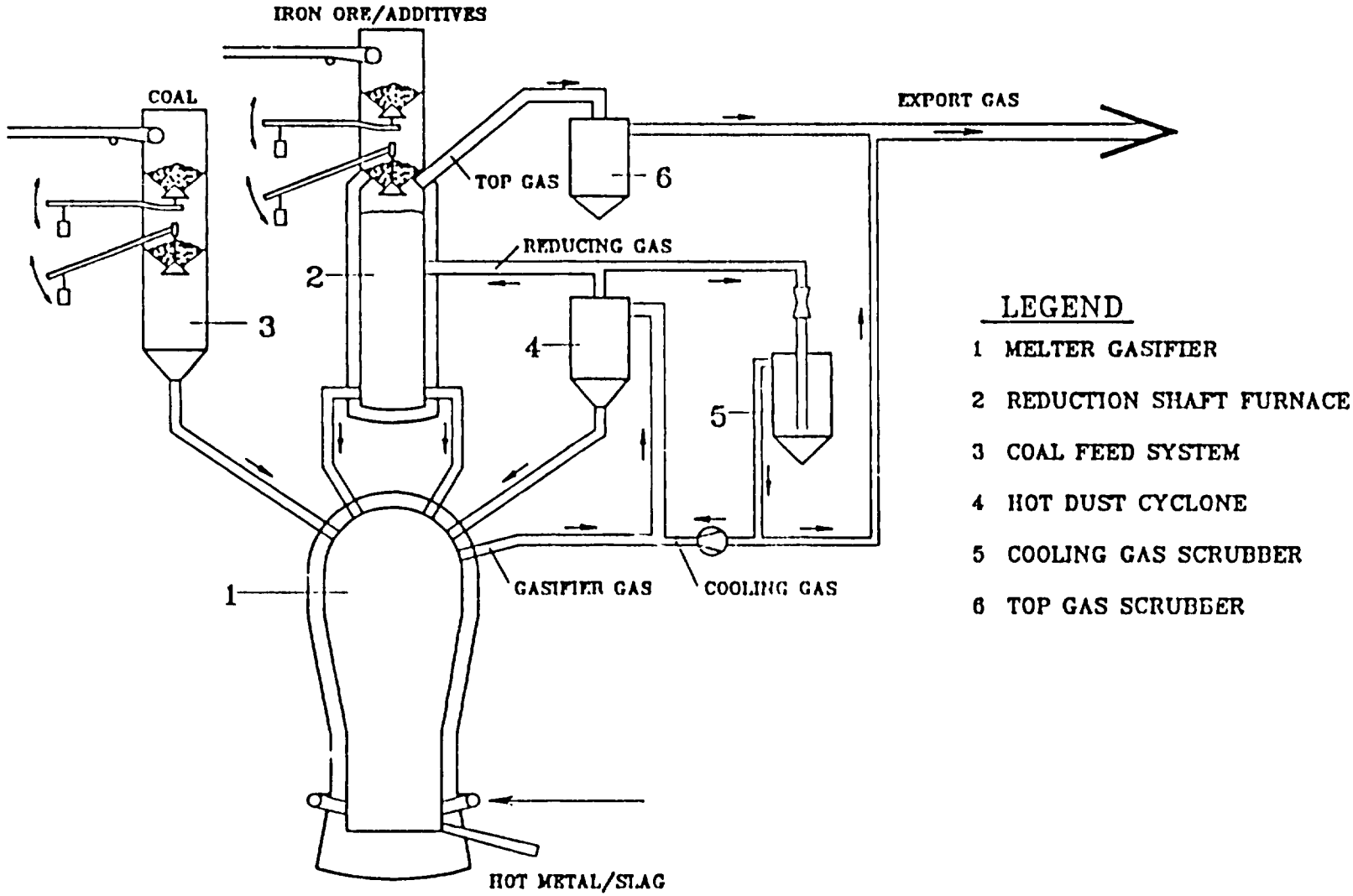
1 Corex - Now a Production Plant at ISCOR Pretroia Works, Rolf Hauk, Deputy Director, and Jurgen Flickenschild, Vice-President, Corex Technology, Deutsche Voest-Alpine Industrieanlagenbau GmbH, Dusseldorf, Germany



THE COREX® PROCESS

BASIC FLOW SHEET WITH EXPORT GAS

FIG. 4

EOF are the following as shown in the attached diagram:

1. The furnace shape is compact with a small surface area to reduce heat losses.
2. The submerged injection tuyeres and the after burning of CO to CO_2 above the bath with oxygen and air and oxy-fuel burners results in a very high heat flux and release of 95% of the chemical energy in the bath and over the bath.
3. The scrap preheater is of a unique design, located above the reaction vessel so that the waste gases pass directly from the furnace through the scrap to the exhaust system.
4. The furnace is provided with a replaceable bottom which permits quick turnaround during the campaigns and results in very high furnace availability.
5. Water cooled side walls and roof which replace refractories and as a result reduce costs and increase furnace availability.
6. A very intense rate of bath oxidation reduces heat losses, increases energy efficiency and increases productivity.
7. Provision is made for the introduction of carbon and lime and other solid materials so that advantage can be taken of many variations in the raw materials.

These important design features, robust and practical construction, have enabled PAINS to have 24 heats in 24 hours with liquid charges of hot metal to scrap in the ratio of 50-60%. The PAINS furnace set up in 1983 is of 28 tons capacity. An additional EOF furnace has been set up at PAINS in Brazil with a capacity of 30 tons in March 1988.

An 80 tons capacity EOF plant is being set up at Tata Steel, Jamshedpur in India, which will yield an annual liquid steel output of 600,000 tons. Another EOF plant of 60 tons capacity at Companhia Siderurgica Aliperti (CSA) went into operation in mid-1988.

Additionally, a 40 tons EOF plant for all steel scrap operation has been ordered at the end of 1988 by Ocean States Steel Corporation at Rhode Island ir. USA with a capacity of 250,000 tons/year of liquid steel.

Figure 5 shows the EOF Scheme.

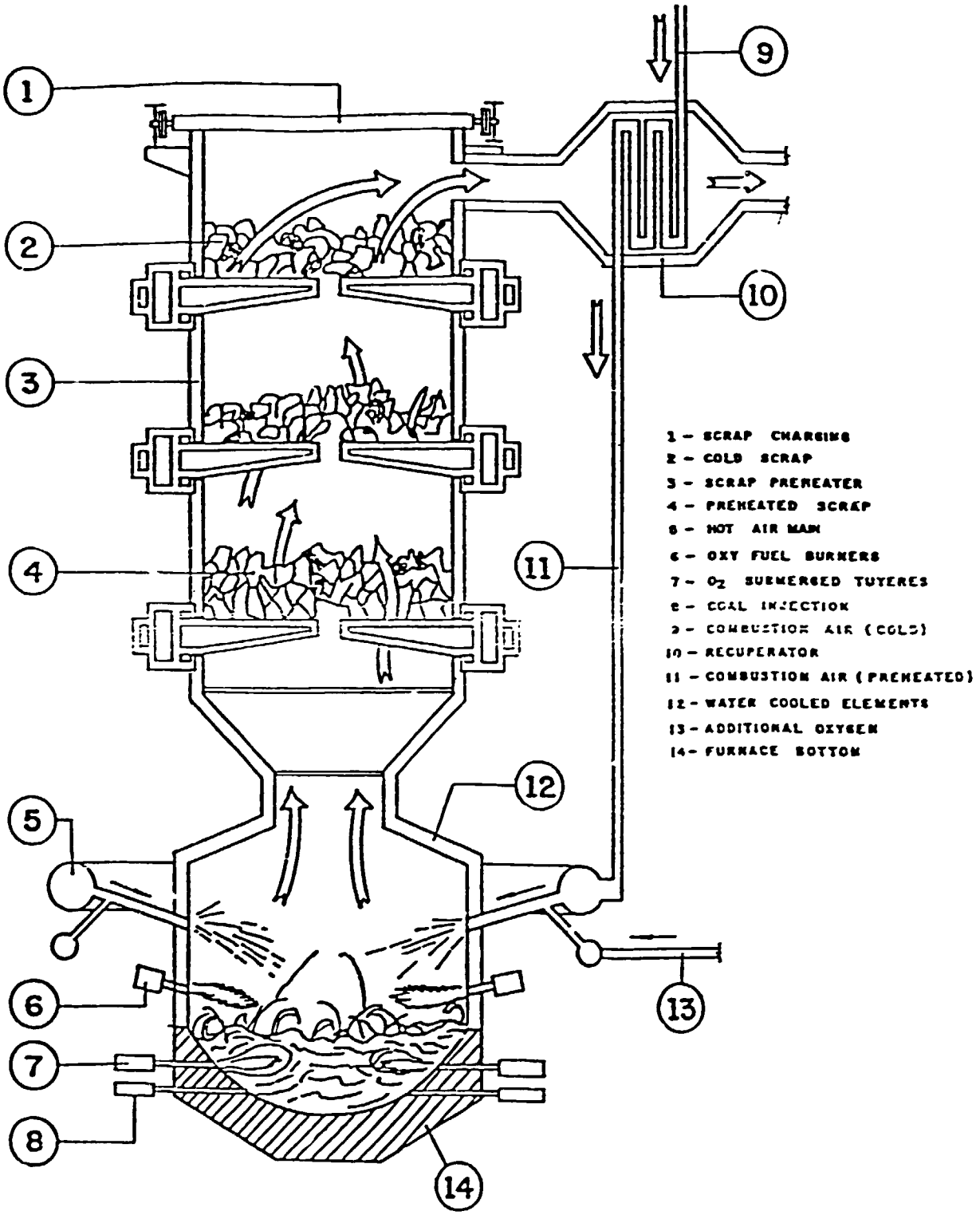


Figure 5 - EOF (Energy Optimizing Furnace) Scheme

Diado Steel Company's Process

Diado Steel Company in Japan has recently developed a new non-electric steel scrap melting reactor/furnace process[1] depicted in Figure 6. It is operated using a carbonaceous material and oxygen as the energy source.

The reactor has a pre-heating room above a melting furnace. The iron bearing materials are pre-heated by the exhaust gases from the melting furnace and then charged into the melting furnace

A co-axial tuyere and a single tube tuyere are provided at the side wall in the bottom of the furnace. Oxygen gas is introduced through the co-axial tuyere at a blowing rate of 400 N/min and nitrogen gas is introduced as a coolant through the outer slit at a blowing rate of 100 N/min. The single tube tuyere is used for carbon power injection (particle size - 0.4 mm) carried by nitrogen at a blowing rate of 300 N/min. Although the fine coal powder which contains volatile matter up to 30% can be used as a carbonaceous material, graphite is used in order to avoid the complex phenomenon caused by the combustion of carbon and hydrogen contained in the volatile matter. The melting furnace is equipped with another tuyere at the upper part of the furnace to introduce oxygen. This tuyere is made in a single tube structure with its tip in alumina. As such, the tuyere is free from oxidation and very stable against the high temperature of the furnace. About 50% of the Co gas generated in the iron bath is converted into CO_2 through the post combustion by the O_2 blown into the upper part of the furnace. Iron and steel scrap is first charged into an antechamer at the top of the melting furnace through a belt conveyor. The antechamber is separated from the preheating chamber by a door so that the scrap can be charged without disturbing the air tightness of the furnace

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[1] Melting of Direct Reduced Iron in a Non-Electric Power Scrap Melting Furnace, Trans of the Iron and Steel Institute of Japan, Vol. 28, No. 12, 1988, pp. 1014-1020.

system. Charging of the scrap can be completed very quickly. The preheating chamber is separated from the melting furnace by 2 doors.

The lower door lined with refractory material shuts off the radiant heat from the inside of the furnace to protect the operating mechanism of the upper door from high temperature. Most interesting results have been obtained by Daido steel with 100% scrap charge using the liquid heel method.

Figure 6 shows the schematic illustration of a Daido Reactor.

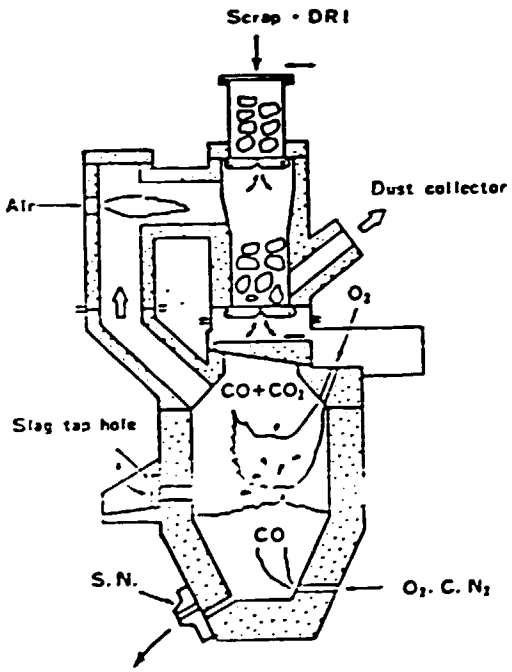

Figure 6 - Schematic Illustration of a New Reactor

Open Slag Bath Smelting in Rectangular Submerged ARC Furnace

While smelt-reduction processes have been figuring in the lime light without any tangible industrial scale success and commercial acceptance so far, there have been developments in smelting pre-reduced materials in open slag bath submerged arc furnace with rectangular hearths with 6 self-baking electrodes.[1]

Cold smelting in submerged arc smelting furnaces started in 1925 in Norway, in 1937 in Finland and in the late 1950's with major industrial installations in Norway (Moirana) and Venezuela (Sidor). These plants entailed high power consumption, about 3000 kWH per ton of iron smelted. Then came the Skopje (Yugoslavia) plant 1966 and the Highveld Steel-Witbank in 1968 in South Africa using hot pre-reduced feed from rotary kilns to circular submerged arc smelting furnaces employing three electrodes. Relevant details of the operations of these two plants were furnished by the writer at the Third Interregional Symposium on the Iron and Steel Industry organized by UNIDO in Brazil in 1973.[2] After the start of the Skopje plant in 1968, serious operational problems and hazards were encountered leading to explosions in the Elkem electric submerged arc smelting furnaces which thereby led to the closure of the six rotary kilns in 1971 for more than a decade. Early 1980, the operations were resumed and some highlights of the pre-1971 operations and post-1980's performance are furnished below.

During 1968-1971, serious decrepitation and degradation of the dried lignite took place in the rotary kilns. The hot pre-reduced charge contained excessive lignite fines which led to explosions in

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1 The direct-steel-smelting process - M. Driemeyer, W. Reichelt, and E. Wagner - Mannesmann Demag, Huettentechnik - UN-ECE Seminar, May 1983 - Netherlands - Steel/SEM.9/R.16

2 An appraisal of some of the direct reduction processes for the production of sponge iron - B. R. Nijhawan - UNIDO - ID/WG.146/118

the Elkem submerged arc smelting furnaces due to extremely poor permeability of the burden and pressure build up therein. For more than 10 years the rotary kiln plant operations were moth-balled until the early 1980's when the Skopje plant operations were resumed with reportedly better results which are outlined herewith from a recent paper.[1]

The iron ore used at Skopje is basically siderite-chamosite with some hematite-magnetitie limonitised ore from Tajmiste mines of the following analysis:

		%
Fe tot	-	41.46
Fe + 2	-	27.7
Fe + 3	-	14.06
SiO_2	-	13.65
CaO	-	3.25
MgO	-	0.95
Al_2O_3	-	5.51
P	-	1.0
S	-	0.23
Moisture	-	2.0

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[1] Lignite technology at the Skopje iron and steel works - UN-ECE Seminar 1983 - Steel/SEM/9/R.15 - held at Noordawijkerhont - NL

Lignite used is in two granulations 15-30 mm and 30-60 mm and of the following chemical composition.

	15-30mm	30-60mm
Fixed C	37.18%	38.10%
Vol.	47.86%	48.95%
Ash	14.98%	12.84%
S	1.55%	1.37%
H_2O	24.90%	26.2%

There are 6 rotary kilns, 95m long with inner and outer diameters of 4.15m and 4.55m respectively with a speed of 0.55 rpm.

The ore, limestone and dolomite are added in exact proportions at the inlet of the kiln while the lignite is added through lignite scoop feeders arranged along the second half of the kiln. Depending upon the requirements, coke is added at the inlet of the kiln or through the lignite scoop feeders. Heat necessary for the reactions to take place in the kiln is provided by burning fuel oil through a central burner located at the outlet of the rotary kiln and by the combustion of volatiles liberated from the lignite. The air needed for combustion of the volatiles is injected through secondary fans placed on the kiln shell through 36 air blowing pipes built into the rotary kiln. The waste gases flow counter current to the charge. The heat of the flame and heat released by the combustion of the volatiles and Co created in the reduction zone, enable the charge to reach a temperature of 1050°C.

There are 5 submerged arc electric furnaces supplied by Elkem with transformer ratings of 34.5 MVA for 3 furnaces and 45 MVA for the other two. The inner diameter of the furnace is 15m and Soderberg electrodes are of 1.9m diameter.

The hot pre-reduced charge has the following analysis:

	%
Fe tot	40.53
Fe + 2	33.97
Fe + 3	1.8
Fe Met	4.77
SiO_2	13.26
CaO	12.24
MgO	2.96
Al_2O^3	5.81
Co_2	2.56
Fixed C	5.59
S	0.41

The pig iron smelted from this hot pre-reduced charge from one furnace gives a daily production of 250-300 tons with power consumption of 1530-1550 KWH/t and electrode consumption of 10 Kg/t.

When using cold charge of iron ore and coke with no pre-reduction, daily output is 150-170 tons of pig iron with power consumption of 3200-3300 KWH/t and electrode consumption of 22 Kg/t. Thus with a hot pre-reduced charge, the pig iron production is increased by 40% and electrode consumption reduced by 50% compared to unreduced cold charge.

Highveld (Witbank-South Africa) has now 7 submerged arc electric smelting furnaces (4 x 45 MVA, one 63 MVA and 2 x 33 MVA) with 13 rotary kilns which yield over one million tons of pig iron annually. Highveld has developed a process to smelt hot pre-reduced charge at levels of about 60% pre-reduction. The power consumption is around 1200 KWH/t and electrode consumption from

6-8 kgs/t of iron. The main objective of Highveld is to produce pig iron with 3.3 to 3.8% C with adequate metalloids for oxygen steel making and optimum recovery of vanadium from the hot metal in shaking oxygen ladles prior to steel making. The high titania content of the pre-reduced charge and flux required to reduce S and P result in 700 kg of slag per ton of iron. The titania rich slag is discarded.

QIT is operating open slag bath electric iron smelting furnaces in Sorel, Canada, and Richards Bay, South Africa for smelting cold feed of iron bearing titanium ores to produce high grade titanium (> 80%) slag for paint pigment with molten iron as a by-product; the Richards Bay Plant is smelting beneficiated beach sands for the same products. These open slag bath smelting furnaces are equipped with 6 in-line semi-baked graphite electrodes of 600 mm diameter. These furnaces are cold fed with ore and carbon with precaution taken to avoid slag foaming. Chrome-magnesite suspended or arched roofs last up to one year despite the severity of operating conditions, corrosive titanium slags, radiated heat and heavy volumes of high temperature hot gases.

Open Slag Bath Smelting With Hot Pre-Reduced Charge in Rectangular Submerged Arc Electric Furnaces With Six In-Line Soderberg Electrodes

New Zealand Steel Company had been operating a direct reduction rotary kiln to produce a 92% metallised product from ilimenite beach sands. The pre-reduced/metallised finely grain-sized (45-212 μm) sand product was fed cold but continuously into conventional electric arc steel making furnace to produce liquid steel along with high volume of slag and equally high power consumption.

During 1985, the New Zealand plant put up 4 rotary kilns for pre-reduction and addition of the hot pre-reduced matallized products to tw), 69 MVA rectangular submerged arc smelting furnaces to yield 720,000 tons of pig iron annually. The new rotary kilns which are 65 m long x 4.5 m diameter were upgraded to increase the bed area which improved the transfer of heat from the gases to the charge. The pre-reduced product metallised 70-80%, along with the char, was charged hot into the

rectangular electric smelting furnaces to produce pig iron with power consumption ranging from 850-950 KwH/ton of iron at an input of 25-30 MW. The electrode consumption is very low at 2.5-3.5 Kg per ton of iron.

These rectangular smelters have six electrodes 1.32 m diameter which are stronger and less prone to fracture. In the open slag bath smelting, the electrodes are immersed in the slag whose resistance determines the power consumption. The open bath furnace is operated at higher effective resistance than conventional circular submerged arc smelting furnace since the electrodes are not affected by the conductivity of the charge. The rectangular furnace can accept fine grain sized feeds without agglomeration. In an orthodox circular submerged arc furnace, the electrodes are subjected to severe physical strains when the burden slips during tapping whereas electrodes in the open bath furnaces are not subject to these physical shocks with minimized thermal effects. Desulphurization is effected through fluxes charged into the rotary kiln and/or to the smelter furnace.

A highly metallised >90% hot continuous feed into the open bath furnace could reduce power consumption to 500-600 KwH/ton of iron with a single furnace producing about 2500 tons of metal daily.

Even semi-steel containing 0.2-0.5% C could be produced which can be further refined in a ladle furnace with a small transformer to produce high quality steels.

A key advantage of the rectangular submerged arc furnace is that it does not have the drawbacks of a batch process involving thermal stresses, and low cost Soderberg electrodes can be used.

In India, in a recent trial, smelting of sponge iron fines has been undertaken in a circular submerged arc furnace to produce high quality low phosphorous pig iron. The sponge iron fines analyzed the following:

	- 6 + 3 mm	-3 mm
	Percentage	
Fe tot	90.48	84.72
FeM	80	70.10
C	0.2	0.68
S	0.017	0.064
P	0.058	0.08
SIO_2	3.56	5.32
AI_2O_3	2.98	4.12
FeO	13.47	18.81
CaO	0.51	0.69

The pig iron smelted from these sponge fines gave phosphorous values as low as 0.02 - 0.03% with sulphur ranging from 0.005 -0.02%, carbon up to 3.5%, Si up to 0.7% and manganese up to 0.09-0.06%.

The power consumption was of the order of 1100 KwH/t of iron smelted. The FeO content of the slag was 2-4% showing abnormally low iron losses with slag basicity of 1.8.

The hot metal produced was an ideal feed for the production of SGI-spheroidal graphite iron - ductile iron for high quality castings.

Elkem has built a plant at Tyssedal in Norway for the production of 100,000 tpy of "Semi-Steel" (partly refined pig iron) and 210,000 tpy of high titania slag. The pre-reduction kiln has been supplied

by Allis-Chalmers and the cyclinderical 3 Soderberg electrode submerged arc furnace is supplied by Elkem. Iron bearing titaniferous ores will be pre-reduced in the rotary kiln. The cold pre-reduced sponge is charged into the Soderberg submerged arc furnace to produce "Semi-Steel" partially refined pig iron and high grade titania slag. The semi-steel is then further refined in a ladle furnace tc produce high quality steel.

Thus this submerged arc open slag bath smelting technology coupled with pre-reduction open up possibilities of producing semi-steel and then finished steel to be much more attractive and pragmatic than the current smelt-reduction processes, at the present stage of their development, can justifiably claim.

Processes based on the above technological pattern such as the "Combismelt" developed by Lurgi jointly with Demag fall into the category of potentially viable industrial projects.

The RHF Iron Making Process (Fastomet Process)

The RHF[1] iron making process (Rotary Hearth Furnace) consists of mixing and pelletizing iron ore and coal fines, drying the pellets on a grate, pre-reducing the dried pellets on a rotary hearth and then charging the hot pellets in a submerged arc furnace (SAF) operating with an open slag bath. Hot metal is tapped into ladles in batches, at intervals dependent upon the requirements for down stream steelmaking. The SAF can also serve as a hot metal reservoir if so required since it can hold up to 4-5 hours of production. Carbon content of the hot metal can be controlled from 0.1 to 3.5%. Desulphurization is very effective in the SAF as also in the ladle using lance injection of CaC_2 or magnesium based reagents.

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[1] Direct from Midrex - 4th Quarter 1989 Report, pp. 6-10. RHF is now termed FASTOMET Process by Midrex.

The hot reduced pellets from the RHF are continuously melted in the SAF whose operations are independent of the RHF.

By charging the quantity of carbon and lime in the charge, hot metal chemistry can be adjusted within the following limits:

Carbon	0.1 - 3.5%
S	0.05 - 0.15%
Si	0.1 - 0.6%
P	0.01 - 0.05%
Temperature	1400 - 1600°C

The hot metal can be refined if it has high C content in the BOF/LD oxygen steel making. If the hot metal is of low carbon content, it can be refined into high quality steel through ladle metallurgy/refining. If normal cast/merchant iron is required, it can be granulated or cast in the pig casting machine.

RHF-Fastonet process can utilize effectively mill scale undersized sinter fines, coke breeze, flue dusts, etc. in producing supplemental hot metal and steel. The key, however, is the pre-reduction followed by SAF technology operating with open slag bath as advocated earlier in this paper.

It will not be out of place to mention that direct reduction processes based on gaseous and coal reductants have in recent years made significant industrial progress particularly in developing countries. After the full success of UNIDO sponsored demonstration plant for the production of sponge iron using non-coking coals at Paloncha in India with an initial capacity of 30,000 tons/year raised to 60,000 tons/year through a second kiln, there have been 6-7 new Indian projects in various stages of implementation while two coal based industrial sponge plants have been completed and started operations in India. These new plants have been based on SL/RN and Krupp CODIR processes in India and the gas based new Indian sponge plants of ESSAR and Grassim are based on Midrex and HYL III respectively. Identical progress is being made in Venezuela about the expanding role of

Midrex while HYL III has consolidated and expanded its capacity in the Mexico (Sicartsa plant). And yet in the developed/advanced countries, the sponge plants are closed or moth-balled.

The lists of DR/sponge plants released periodically by Midrex and other agencies depict the rosy and dismal status of the DR/sponge plants in the developing and developed countries respectively. It is stressed that much patience is called for in advocating new technologies and processes and pressing them through to industrial adolescence and commercial acceptance. The revolutionary technologies and developments in electric arc steelmaking practices, equipment, plant operations and results achieved in recent years for Mini Steel Plants worldwide, are tributes to such dogged patience and exercise. The plants and processes that have fallen by the way side such as at Inchon in South Korea, Purofer in Brazil, Armco in USA, etc. have been the casualties in the global progress of direct-reduction/sponge production technologies and industrial plants now operating successfully.

A Word of Caution

In the case of some of the emerging relatively new technologies that have still to cut their industrial teeth, attempts are made to empirically extrapolate their production costs on industrial scale even when there is no industrial plant yet installed to prove or disprove their industrial sale techno-economic data and implied performance. In the maze of vastly conflicting data and in the wake of current economic depression in some industrially well developed parts of the world, one is left to his own pragmatic analyses to suit particular markets and raw materials and derive his own conclusions. And today, of course, the customer/client is not supposed to be always right.

Furthermore, the cost data for a specific process calculated for a particular country/region do not lend themselves to universal/global acceptance. There are some excellent papers/reports recently published providing the economic data and production costs to cover most of the newer technologies/processes, proved technologies and well established processes under trials on pilot plant

scale; in the case of the latter, commercial cost data have been extrapolated albeit without any commercial plant operating anywhere. The point(s) one would seek to emphasize is that economic study of newer processes/technologies today presents a fast and vastly changing spectrum and can by no means be accepted universally for all countries, for all conditions/environments and for all the time to come.

During the last few years several international conferences/symposia have been held in the developing and developed countries on the above subjects. Some processes that had until recently withstood the onslaught of the critics, have finally dropped out while others have proved their mettle/ground and are finding increasing applications/acceptance.

Pulverized Coal Injection in the Blast Furnace for Iron Smelting/Production

The 1980's have seen wide spread adaption of pulverized coal injection (PCI) in the blast furnaces in Japan which enables costly coking coals to be replaced with lower grades of pulverized coal. PCI has been in fact, widely employed in most of the steel producing countries of the world. After pulverization of the coal, injection lances blow it into the blast furnace through the tuyeres. Over 120 kgs of coal per ton of hot metal are injected through the tuyeres of the blast furnace. The injection of pulverized coal with the blast furnace is now a well established technology. The rate of PCI has now been raised to 150 Kg/ton of hot metal and even 180 kg/ton of hot metal has been undertaken in Europe. The use of 200 kg of coal per ton of hot metal and even 300 kg appears achievable with only moderate changes in the blast furnace practice such as O_2 enrichment of the air blast. PCI is now undertaken very widely in the developed steel producing countries as also developing countries such as India, China, South Korea, etc. Oxy-coal injection at the Cleveland Iron Works in the UK with oxygen injection directly at the tuyeres have shown outstanding results with coal injection exceeding 220 Kg/thm.

Some Latest Smelt Reduction Technologies in Experimental Stages Only

The processes outlined here are operating on Pilot Plant Stage and have not so far come into commercial production stages. AISI Direct Steelmaking project has taken a lead in direct steelmaking investigations. A pilot plant has been set up in June 1990 with the following objectives:

- Elimination of coke ovens, blast furnace and agglomeration plants
- Operational flexibility
- Simplification of facilities
- Scrap melting
- Lower capital costs
- Minimum pollution

The U.S. Department of Energy is heavily subsidizing the AISI project. The pilot plant consists of a pear shaped vessel holding liquid iron. Iron ore pellets, coal and flux are continuously fed into this vessel while oxygen is blown in through a lance to burn the coal which produces the requisite heat and chemical reactions for iron ore reduction. The aim is to produce liquid iron containing 3.5% carbon which can then be refined by oxygen to produce steel.

Since 1988, eight major steel producing companies in Japan along with the Japanese Coal Mining Research Center has embarked upon a Direct Iron Ore Smelting Process (DIOS). Should the development work prove successful in all its aims, the following results could be expected using the DIOS process.

- Brings flexibility in the choice of raw materials because of the direct use of iron ore and coal.
- Better response to changes in production demands.
- Reduced capital and operational costs.
- Higher flexibility in the generation of energy.

- Reduction of energy consumption and reduced CO_2 generation by the use of non-coking coal, which is a fuel containing appreciable content of hydrogen.

H1 smelt process, after 6 years of operation is a small pilot plant, is now in the process of establishing parameters for design, construction and operation of a 100,000 ton/year plant to establish its commercial feasibility. If the current efforts for larger scale operations succeed, further intensive work will be needed to install a commercial plant with a capacity 0-5 million ton/year capacity for the production of molten iron.

Jumbo Coke Making Reactors

In Europe, coke making technologies are poised to take a strident leap into a new advanced system called "Jumbo Cokemaking" Reactor with capacities around 2 million tons/year or more from a single battery of reactors. According to current plans, these Jumbo Cokemaking batteries will become available in the second half of the 1990's. The two experimental reactors now being developed by Deutsche Montain Technologies, Essen in Germany in collaboration with Ruhrkolhe AG are scheduled for operations in 1992-1993. The new cokemaking technology is environmental friendly and can use coals of inferior grade than those high grade coking coals used at present. Jumbo coke ovens will produce a better coke with much higher coke yield and lower energy consumption. It is also claimed that Jumbo coke ovens will lead to an overall effective cost reduction of 20% compared to the operating costs of conventional coke ovens currently in use. The productivity will be 150 tons of coke per reactor. The thermal efficiency of Jumbo coke oven reactors will be as high as 70% compared to only 38% in the case of conventional coke ovens.

The experimental technologies outlined above have still to cut their industrial teeth and industrial scale upgrading may take several years to come.

Figure 7a shows the simplified flow steel for the H1 smelt process as developed at the H1 Smelt Research and Development facility in Kwinana, W. Australia.

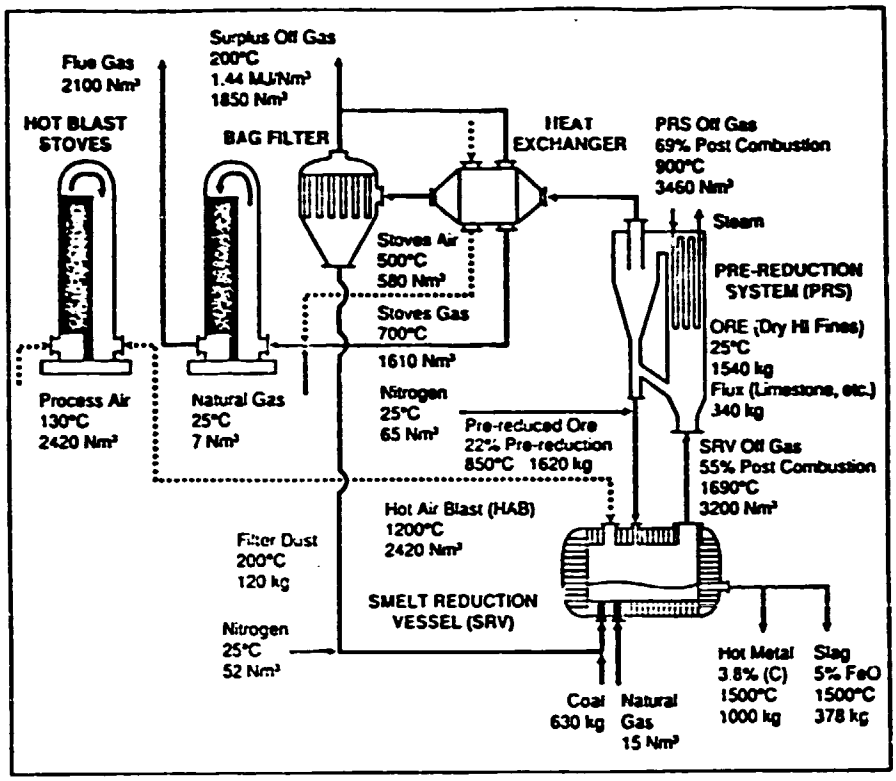


Figure 7a - Hismelt - Simplified Process Flowsheet

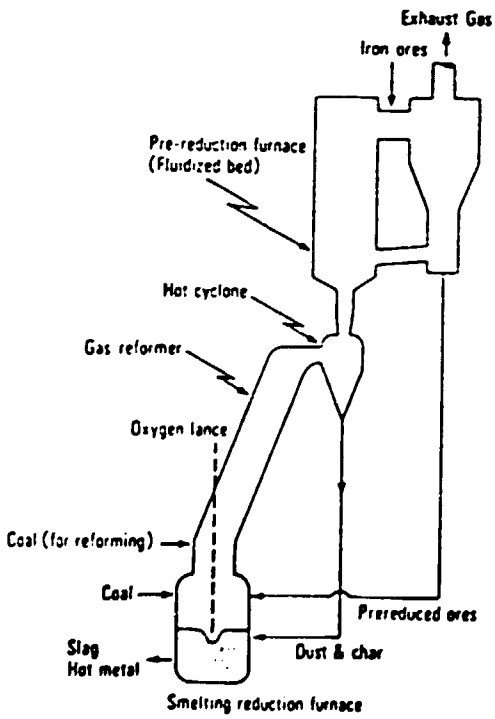


Figure 7b - Concept of JISF's Smelting Reduction Process (DIOS Process)

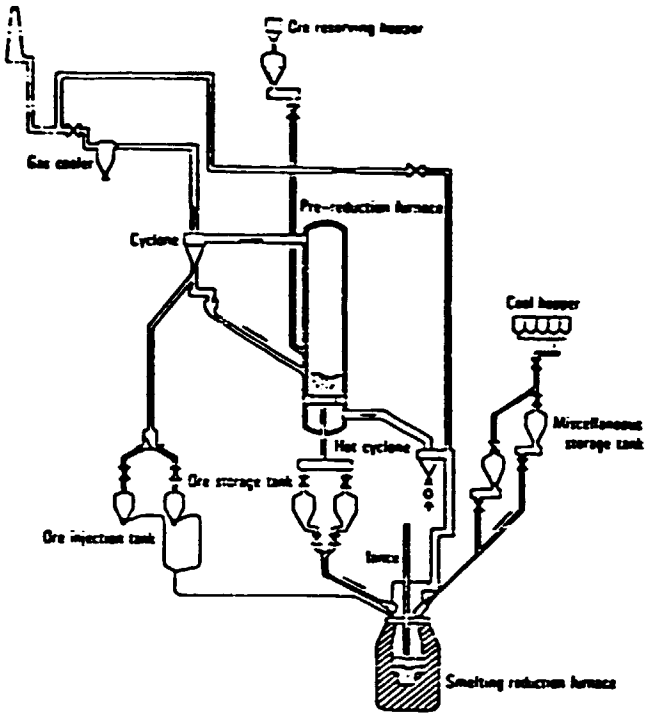


Figure 7c - Experimental Smelting Reduction Furnace (NKK, Fukuyama Works)

Figure 7b shows the concept of JISF's smelting reduction process (DIOS process) and 7c depicts the Experimental Smelting Reduction of NKK, Fukuyama Works.

Thin Slab Continuous Casting

SMS-CSP Technology

NUCOR plant at Crawfordsville, Indiana, USA has changed the outlook of many concerning flat rolling and continusous casting. NUCOR broke into the black in 1990 just one year after its start-up in 1989. Now it operates at its maximum capacity and the yield of the finest quality sheets reached higher than 80%. The manufacturing cost of hot rolled coil in July 1991 was 267 US$ per ton which is lower by US$ 50 to 100 per ton compared to the conventional slab casting in integrated steel mills. There are about 400 employees only for the annual production of 0.8 million tons of hot rolled coil and 0.35 million tons of cold rolled coil. It takes a total only of 3.5 hours from charging scrap and

sponge DRI, etc. in the electric arc furnace to the finished hot rolled coil. NUCOR has many ambitious plans for upgrading and expansion. Hot rolling mills will have another rolling stand (5th stand) and a hot dip galvanizing line will be installed in 1992. The second NUCOR plant for compact strip production (CSP) - one million tons annual capacity is under installatiion at Hickman in Arkansas; it will produce 1 million tons of hot rolled coils with 2 DC electric arc furnaces and a 6 stand hot rolling mill. The thickness of the hot rolled coil will be 1.8 to 2.7 mm with maximum width of 1500 mm. NUCOR, Crawfordsville thin slab caster is selling its rolled steel coils at an amazingly low price. The present base price for 1000 ton buyers of hot rolled coil is $260 per ton (actual weight basis) and for cold rolled coil is only $360 per ton. The steel is offered on a uniform basis in the domestic and international market, i.e., the F.O.B. price for the steel is the same for all. NUCOR, Crawfordsville does not freight equalize under any condition.

A typical conventional flat products plant employs 4 to 6 manhours of labor per ton of flat product produced and shipped while NUCOR thin slab caster utilizes only 1-5 manhours per ton of shipment; the manhours required for producing rolled hot coil is only 0.7 manhour per ton of shipment.

The fine grain structure of the steel from the outer edge to the center, due to rapid solidification in the thin clab caster permits it to have above average drawing characteristics. The metallurgical characteristics of the liquid steel have been good, reflecting the plant's modern steelmaking practices and ladle metallurgy practice.

DRI/sponge has been used at NUCOR up to 20% of the metallic charge in the EAF shop - DRI/sponge has been imported from USSR, Venezuela, et. at CIF cost of 120$ per metric ton. DRI/sponge with its very low residuals is an excellet feed for NUCOR EAF and produces high quality steel for the ladle metalluray operation.

Figures 8a, 8b, and 8c show the basic principle of the CSP technology and its comparison with the conventional plant and the growth of the monthly production of NUCOR-Crawfordsville, Indiana in USA based SMS-CSP technology, respectively.

NUCOR's second thin slab/flat rolling plant at Hickman, Arkansas will be similar to the Crawfordsville plant. The thickness of the cast slab 40-50mm; cast at a speed of 4.5 meters per minute. The Arkansas mill will have 6 finishing stands which will permit the production of the strip to a thickness of 0.071 inch (1.775 mm) and a possible 0.067 inch (1.675 mm). Hickman will utilize D.C. electric steelmaking furnaces.

By the year 2000, 4 to 6 thin slab casters may be operating in the USA and Canada. The annual hot rolled coil capacity of these mills could be around 4 million tons and possibly 7 million tons.

NUCOR's second thin slab casting/flat rolling mill now under construction at Hickman, Arkansas with a capacity of 1 million tons per year will start up in 1993. It will have six - 4 high hot rolling stands.

Geneva Steel at Geneva Vineyard, Utah, USA is installing a unique continuous center from SMS Concast, that will produce a slab that is 120" wide with a thickness of 2" to 10". The slab will be directly in-line rolled to hot rolled coil or flat. The capacity of this plant which will replace ingot producing facilities will be 2.5 million tons per year.

Chaparral Steel (USA) is considering a breakthrough facility with a capacity of 0.8 million tons/year which will produce hot rolled coils about 50" wide. The thin continuously cast slab will have an initial thickness of about 80 mm (3.15 inches) and may still be connected to the continuous caster while being rolled. Hot rolled coil will be as thin as 0.03 inch (0.75 mm) which is probably thinner than any other hot strip mill in the world. Thus, there will be a continuous strip of steel from the thin slab center through the hot strip mill and into the down coiler. Only after the coil has reached a sufficient size will the sheets be cut - a remarkable mill indeed.

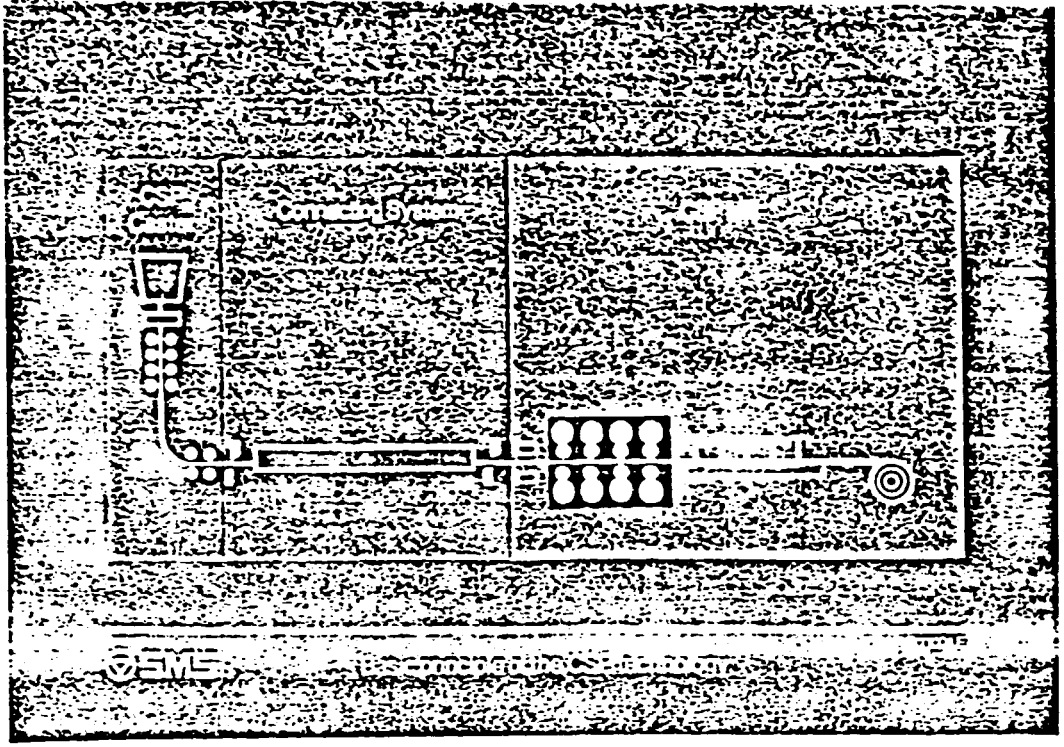


Figure 8a

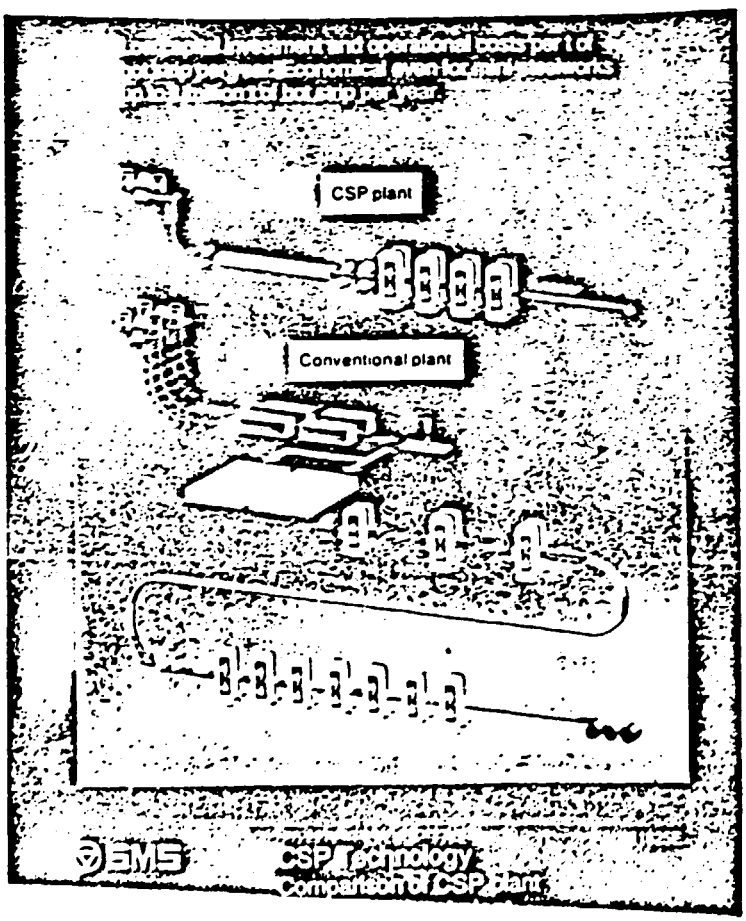


Figure 8b

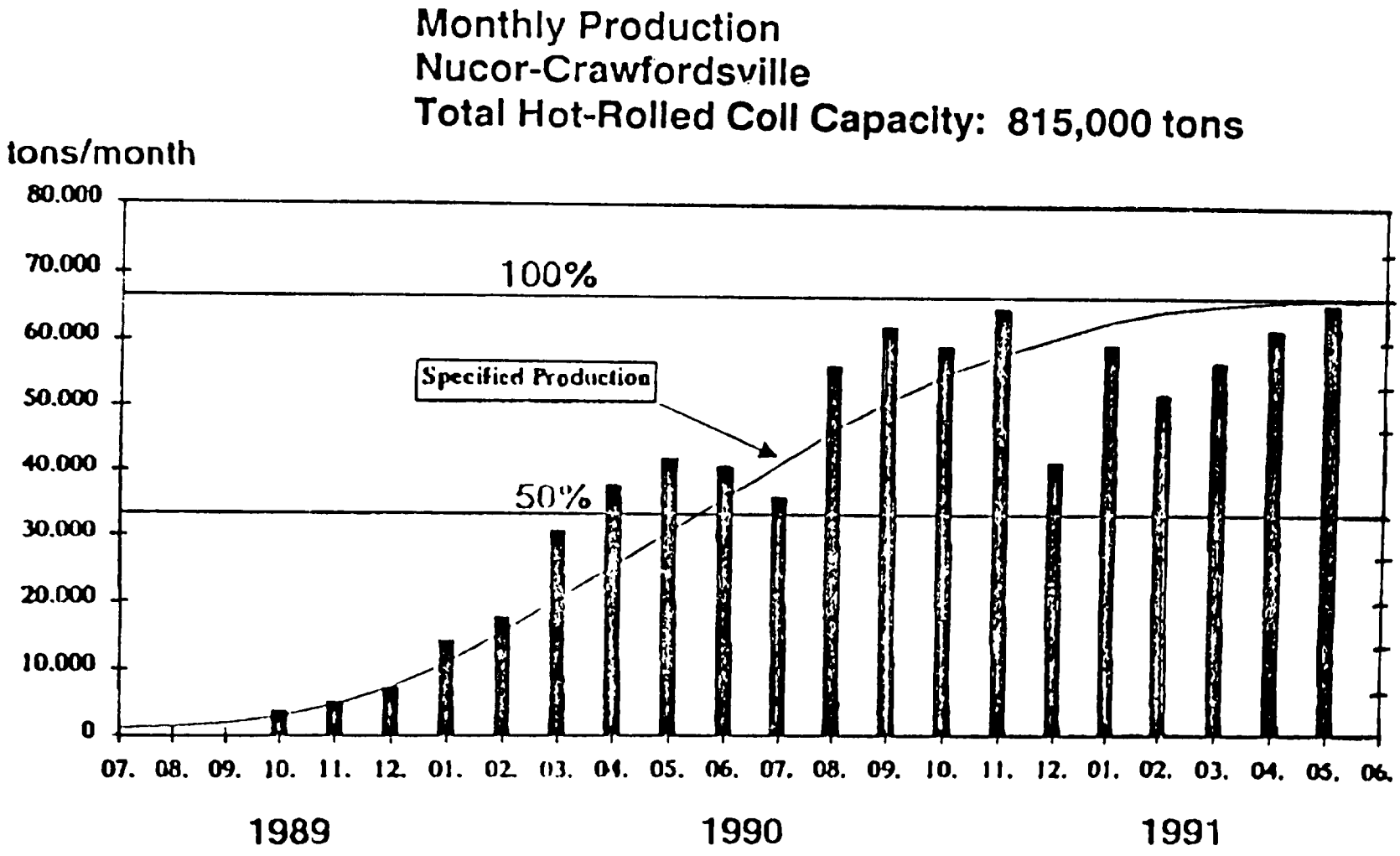

Monthly Production
Nucor-Crawfordsville
Total Hot-Rolled Coil Capacity: 815,000 tons
tons/month
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
100%
50%
Specified Production
07. 08. 09. 10. 11. 12. 01. 02. 03. 04. 05. 06. 07. 08. 09. 10. 11. 12. 01. 02. 03. 04. 05. 06.
1989
1990
1991

Figure 8c

Mannesman-Demag Huttentichnik (MDH) I.S.P.

Thin Slab Mill (Cremona - Arvedi - Italy)

At the end of 1991, Cremona will have a steel plant offering a 100 ton, Demag AEF for slag free eccentric bottom tapping as well as a 100 tons ladle furnace. These facilities will, for the first time ever, make hot strip on ISP installation (in-line-strip production) in special stainless and carbon steel grades. The ISP is a joint development of Arvedi and Mannesman-Dewag for a new future oriented technology. The capacity of this new line will be 0.5 million tons/year. The technical highlights of the ISP plant are: liquid steel will be cast and over a length of only 160 meters processed into hot strip with a minimum thickness of 1.2 mm and widths ranging from 650-1330 mm. Such compact design is enabled by the first large scale application of cast rolling technology with the aid of which the thickness is reduced during solidification from 60 to 40 mm and immediately after solidification from 40-15 mm. The salient features are favorable low capital costs compared to other thin slab casting lines without cast rolling technology, minimum transformation energy costs and optimization of surface quality and mechanical properties. While the SMS-CSP process uses a thin slab plant to produce a 2" thick slab for subsequent hot and cold rolling in a 4-stands - 4-high hot strip mill and a reversing 4-high cold mill, the MDH-Arvedi technology produces a 2" slab in the mold but immediately rolls it down to a half that while the strand core is still molten and then completes the process in the high reduction and finishing strands. MDH-Arvedi ISP entry into the near-net shape casting/continuous processing line differs from the SMS-CSP technology in several ways. MDH mold has parallel faces all the way, a feature MDH claims yields less strand deformation and other benefits. Immediately below the mold, in-line powered rolls start slab-thickness reduction while the strand core is still molten, doing it in small increments to avoid solidification problems. Exiting the mold, the strand is descaled, straightened, induction heated to equalize the

temperature and sheared before further processing. All sheared slabs are heated to rolling temperatures in another induction furnace fed by an insulated roller table and then are sent to a coiler furnace called a Cremona Box. Plate grade material is removed from the system at this point while sheet grades are again descaled and rolled to final dimensions in the four finishing stands. Total length of the Cremona (Arvedi) plant is 590 feet, a shade longer than NUCOR, Crawfordsville normalizing furnace alone. Both SMS-CSP and MDH-ISP supply high degrees of automation with their installations, including hydraulic automatic gauge control and other sophisticated features.

Alleghany Ludlum Corporation (US) is the leading US specialty steel producer and Voest-Alpine Industrieanlagenbau (Austrian) mill builders are getting their joint venture directly cast-carbon and stainless steel strip plant called Coilcast/Conroll ready for an early 1992 commissioning at Lockport, New York (USA). Both companies say strip mill investment and operational costs can be slashed by 75% by eliminating even more processing steps than the thin slab route. Thus in 1988, Allegheny Ludlum combined forces with Voest-Alpine which had been working along similar lines, most notably with Sweden's AVESTA AB on a thin slab caster for stainless steel, to take advantage of each company's developments. The prototype coil cast machine is being installed by Voest Alpine at Allegheny's Lockport plant which has 3-15 ton electric arc melting furnaces, an AOD vessel and other melt' ıg and refining units. The caster is designed to produce up to 45,000 pound coils in thickness up to 0.12 inch (3 mm) and up to 48" (1220 mm) wide.

SMS-CSP technology corresponds in principle to that of conventional continuous casting process even though the strand never stops moving until it exits the hot mill and is coiled; SMS system involves a casting machine, a reheat furnace and a rolling train. Although the caster mold is unique in being shaped like a semi-flatted funnel at the top to accommodate a submerged nozzle, it straightens out down its length so that a slab with parallel faces emerges

from the bottom. An abbreviated bending radius, which helps the caster (a low head machine) leads to a straightener and a shear that sends the 1.97" thick (50 mm thick), 53 inches wide (1335 mm) slab into a long (537 feet at Crawfordsville) soaking furnace connecting the caster to the hot strip mill. In the mill's, 4 continuous 4-high stands, slabs are reduced to a thickness range of 0.010" (2.5 mm) to 0.50" (12.7 mm) and coiled at 24 tons maximum weight. Thicker product is sold as coiled plate while strip is marketed as hot coil and/or pickled and cold rolled for thinner gauges. Based on a rated capacity of 800,000 tons/year, the plant cost $265M to NUCOR or $331 per ton capacity. However, NUCOR's second plant at Hickman, Arkansas (US) with 1 million tons/year capacity will cost 300 million dollars, i.e., $300 per ton capacity installed.

Every major steel producer in Japan has been involved in one or more thin slab, strip or thin strip near net shape continuous casting R & D programs. Japan has at least 26 such undertakings in a worldwide total of 81 followed by USA with 15 and Germany with 11 despite rumored Japanese concern about finished product quality. The Pilot Plant at Buschhulten (Germany) of SMS-CSP technology started producing thin slabs in 1985. The signing of a plant supply contract in September 1989, when confirmed into a firm order, will make Taiwan's Yieh Loong Group, the first "post-NUCOR" electric steel maker to opt for CSP-SMS thin slab casting.

Table 10 depicts the NEAR-NET shape casting facilities in Europe.

Table 10
Near-Net-Shape Casting Activities in Europe

Table 10. Near-net-shape casing activities in Europe

COUNTRY	PROCESS	COMPANY	THICKNESS (MM)	WIDTH (MM)	SCALE	FURNACE	STATUS
AUSTRIA	Single Roll	Voest-Alpine	0.5/1	250	Hot model	5 t	Allegheny co-op. started 89
	Twin roll	Voest-Alpine	0.5-8	250	Hot model		
	Oscillating mold	Voest-Alpine	80	1290	Pilot		
FRANCE	Single roll	Irsid (Eureka)	0.5 - 1.2	200	Hot model	300 kg-8 t	
	Twin roll	Clecim	1.5/12	200	Hot model	300 kg	stopped 75
	Twin roll	Irsid	10/2	200	Hot model	300 kg-8t	
	Twin roll	Irsid-Clecim	1.5-5	800	Prototype		starts 91
GERMANY	Belt & roll	Clausthal University	5/10	150	Hot model	500 kg	started 89
	Hazelett twin belt	Krupp Stahl	20-40	400	Pilot		stopped 86
	Oscillating mold	Mannesmann Demag	25	1900	Pilot	220 t	
	Oscillating mold	SMS Buschhutten	60-40	1600	Pilot		
	Osc. mold + rolls	Thyssen/SMS/U + S	40-10	1200	Pilot		started 89
	Roll & roll	Krupp Stahl, VDM	2	600	Prototype	10 t	started 89
	Single roll	Krupp Stahl, Siegen	2		Hot model		started 89
	Single roll	Thyssen Stahl	<1	200	Hot model	60 kg	
	Spray casting	Mannesmann Demag	15	800	Prototype		
	Twin roll	MPI	2	100	Research		
	Twin roll	ZFW	1	110	Research		
	Twin roll	Thyssen Stahl/IBF	1-5	150	Hot model	100 kg	
ITALY	Twin roll	CSM	5-25	150	Hot model	300 kg	
	Twin roll	CSM	5-25	400/700	Prototype	4-20 t	started 89
	Twin roll	Danieli			Hot model		
	Oscillating mold	Danieli	50	1750	Pilot	30 t	
	Oscillating mold	Arvedi/MDH	15	1330	Industrial	Incl. 4 rolling stands	starts 91
SWEDEN	Oscillating mold	Avesta/Voest-Alpine	1870	80	Industrial		started 89
	Twin mold	ABB Royal Inst. Techn.			Hot model		
SWITZERLAND	Twin roll	Concast Service			Design		
U. KINGDOM	Horizontal train	British Steel	15-75	500	Prototype	4 t	
	Twin roll + slurry	British Steel	2	76	Hot model	250 kg	
	Twin roll + slurry	British Steel	3	400	Prototype	4 t	

Figure 11 depicts the NEAR net shape casting processes in Europe.

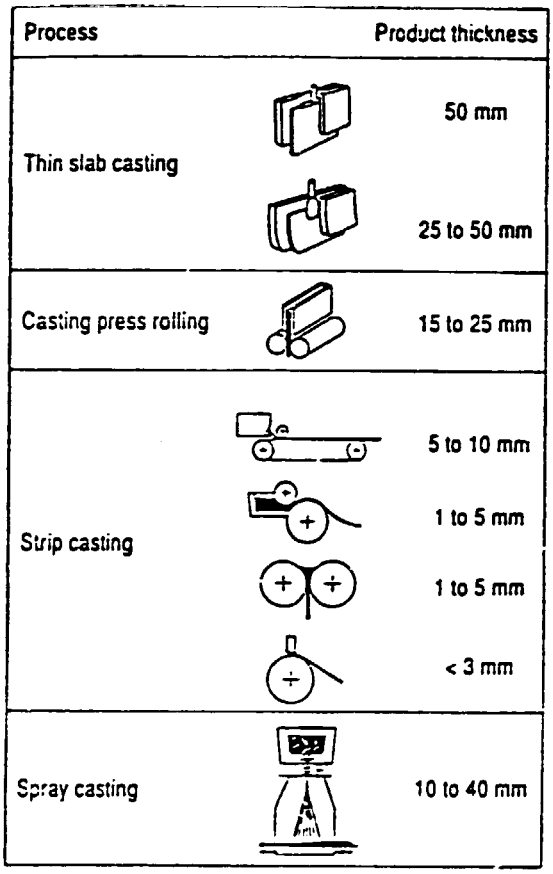


Figure 11 Near-net shape casting processes in Europe

The CPR-Casting Press Rolling process is a joint development of Thyssen, USINOR-Sacilor and SMS. The principle of the CPR process is shown in Figure 12. It consists of a 1.0 meter long mold of SMS type and immediately below it, 2 press rolls which are meant to close the liquid pool by mechanical force and withdraw the slab from the mold. A bending roll then pushes the thin slab with a 2.3 meter radius curve to enter into an unbending unit which is also power driven. Casting speed in the mold is of the same magnitude as the CSP technology. In principle the 2 press rolls weld together the 2 shells solidified on the broad faces of the mold

Figure 12

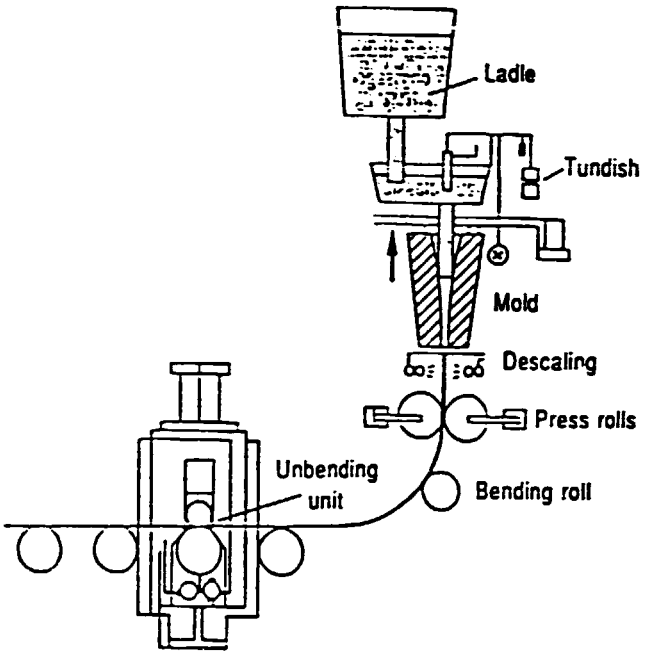


Figure12. The casting press rolling (CPR) process

and to hot work the thin slab and roll it down to a thinner gauge. A secondary water spray cooling and a support of the shell by a grid are provided between the mold and the press rolls to limit bulging and protect the equipment. Such a caster is in principle capable of producing .35 to 0.50 million tons/year. The Ruhroet Pilot Plant installed in the steel shop is fed by a 30 ton ladle tapped from the BOF/LD converter. It is capable of casting 1200 mm wide thin slabs. The product is collected on a 130 m long runner table. Started in May 1989, this Pilot Plant has been in use continuously with carbon and stainless steels. The developing countries would be well advised to study these developments and judiciously apply them in their own countries such as for example Taiwan's Yieh Loong Group is doing to apply for the SMS-CSP technology for thin slab casting and rolling for slab products.

Danieli has already built a conventional slab caster for Feng Lung Steel, Taiwan, where it is possible to cast 1220 mm wide slabs down to a thickness of 75 mm (3 inches). For thinner sections, Danieli has been developing a thin slab caster, using a Pilot Plant at Udine (Italy) since 1986. Danieli is designing 4 plants with each unit having a capacity of 0.6 million tons/year of hot strip, using a thin slab caster (50-75 mm) thick slabs, an equalization furnace and an in-line hot strip rolling mill.

Secondary Steel Making/Ladle Metallurgy

Whilst world steel production figures have not kept pace and fulfilled world steel forecasts made during the last decade and more by multiple agencies, in meeting the steel quality requirements in terms of clean steel and homogeneous chemical composition, the world steel has made remarkable progress mainly through secondary steel making/steel refining and ladle metallurgy processes and innovations.

Important secondary steel making processes developed during the last few decades are vacuum degassing, vacuum oxygen decarburization, vacuum circulation and the ladle metallurgy operations. So revolutionary have been the developments leading to a diversity of multiple operations, their permutation and combination and multiplication of their nomenclature and trade names, that one tends to lose all perspective and attempts to standardize and rationalize the technology. Here the theme is everyone for himself and the concepts of secondary steel making processes and plants are based on local conditions, market demands and quality control specifications.

Not only have vacuum degassing plants and ladle furnace equipment and plants been designed and set up but also combinations like VD, VOD and LF plants and a host of other titles signifying breakthroughs, are leading the trade.

Shifting of metallurgical technologies to secondary refining processes with logical plant and equipment related developments the world over, have led to the general connotation of Secondary Metallurgy or secondary steel making/steel refining.

Secondary Metallurgy

Metallurgical criteria of second metallurgy are based to meet the following demands:

- Upgrading the degree of purity to highest standards
- Lowering the impurity and metalloids contents
- Uniform molten temperature control
- Fully homogeneous chemical composition
- Upscaling the yield figures
- Downscaling the energy consumption figures
- Relieving the primary melting units of doing final refining and finishing operations

The objectives of secondary steel making including ladle metallurgy operations are:

- Effective quick desulphurization, decarburization and deoxidation with minimum metallic and alloying elemental losses.
- Effective degassing of hydrogen, oxygen and nitrogen
- Optimum alloying and recovery figures
- Final homogenization of the melts and resultant finished products

To achieve the above requirements, ladle metallurgy is applied based on:

- Gas stirring by argon/nitrogen lances
- Scrap and alloying elements additions
- Aluminum wire injection
- Powder injectants of Ca, Si, CaO, CaF2, CaC2, etc.

- Top slag additions
- Temperature and oxygen activity measurements

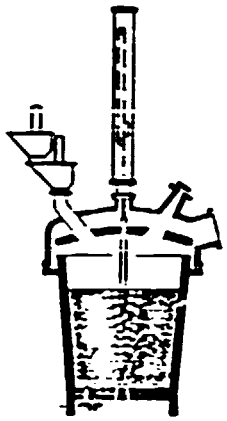
The list is hardly complete. The options cover newer technology and treatment schedules such as degassing of pouring stream, casting under vacuum, and induction stirring.

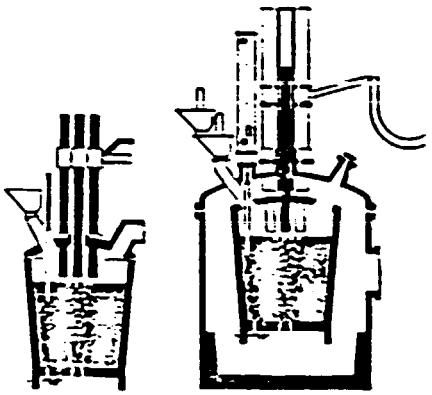
There is a justification for each process as a link in the overall production chain.

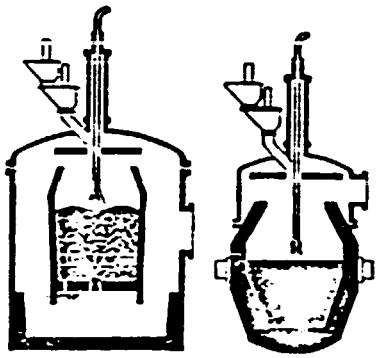
The most suitable process and the optimum and efficient plant configuration in each and specific case has to be determined in the planning phases by combining appropriate plant modules and technological expertise.

A broad spectrum of cost effective ladle sealing and tank processes are furnished herewith in Figures 13 through 18.

Figure 13







Ladle degassing

Ladle degassing is a versatile tool for secondary steelmaking. During treatment the ladle is sealed with a vacuum tight cover or, alternatively, placed into a vacuum tank. With the assistance of an up-to-date inert gas stirring system the liquid steel is agitated efficiently to produce homogenisation in temperature and anlysis. At the same time the reactive surface area is increased and results not only in reduced hydrogen, oxygen and nitrogen levels, but also in low sulphur content of the liquid steel.

Special features

- Saving in tap to tap times
- Very low hydrogen values after short treatment times
- Desulphurisation down to very low levels
- Vacuum decarburisation down to less than 0.002 % C
- Exceptionally good separation of non-metallic inclusions, hence clean steel
- Addition of alloy materials for vacuum metallurgical treatments
- Achievement of tight analytical tolerances
- Chemical and thermal homogenisation
- Sampling, temperature and EMF measurement under vacuum
- Low investment cost
- High availability with low maintenance effort
- Possibility to modify to a vacuum oxygen decarburisation or arc heating plant.

Arc heating (ladle furnace and VAD-vacuum arc degassing)

Arc heating/ladle furnaces increase the productivity of the melting furnace, their purpose is to aid temperature and analysis control. VACMETAL offer a plant configuration which is cost-beneficial not only from a production and maintenance point of view but also in availability.
The VAD unit offers both heating and degassing of the liquid steel. Currently ladle furnaces are used in conjunction with electric arc melting furnace and basic oxygen steelmaking plants when rapid sequencing of casts is required. They serve to control the exacting temperature requirements which are essential for successful continuous casting practices. VACMETAL installations are achieving 48 casts in sequence in two days, increasing steelplant productivity and throughput. Ladle furnaces can act as holding furnaces or buffers in the scheduling of heavy castings or forgings, particularly when the melting furnace capacity is limited in tonnage. In order to avoid pick-up of gases from the atmosphere the teeming of the steel takes place in vacuum or under protection of inert gas shrouding.

Special features

- Increase in productivity of the steelmaking furnace
- Overall saving in costs of production
- Improved alloy recovery
- Ladle and vacuum metallurgical treatment of steel by alloy additions
- Exact analysis control
- Achievement of excellent degrees of cleanness
- Lowest levels of hydrogen, oxygen and sulphur in the steel
- Exact temperature control
- Sampling, temperature and EMF measurements in vacuum
- Use as holding furnace in order to avoid backcharging when delays occur at continuous casting machine
- Special design of vacuum arc heating equipment without electrode arms
- High heating rates
- Heating and vacuum treatment without intermediate ladle transfer

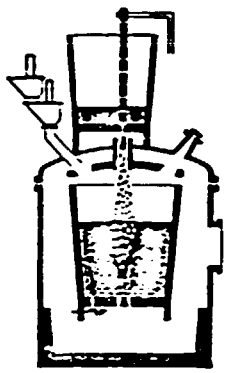
VACMETAL – vacuum oxygen decarburisation process in ladle (VOD) o in converter (VODC)

The blowing of oxygen under vacuum conditions offers a time and cost saving method for the production of stainless, corrosion- and heat-resistant steels, which are difficult or impossible to produce with conventional methods.
The application of vacuum metallurgy is enhanced by the use of oxygen refining.
The significant feature of this process is the cost-beneficial production of high chrome steels with very low carbon, nitrogen and hydrogen levels.
Another application of this process is the heating of low and medium alloy steels by the oxidation of aluminium, carbon and silicon.

Special features

- Vacuum decarburisation from virtually any initial carbon level
- Controlled achievement of extremely low carbon, nitrogen, hydrogen and sulphur contents
- Achievement of qualities with exacting specifications, for example, high-chromium containing steel grades with C + N less than 150 p.p.m.
- Small chromium loss, hence low requirements for reducing reagents and slagformers
- Use of low cost ferro alloys
- Achievement of tight chemical analysis
- Exact temperature control
- Significant increase in productivity of steelmaking furnace
- Reduction in steelmaking costs
- Versatility of plant – can be used also for ladle degassing and for heating of casts

Figure 14



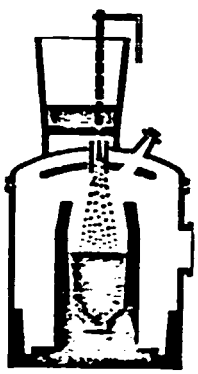
BV-ladle to ladle stream degassing

This process is a variation of the BV-stream degassing process. In this instance the steel is teemed into a second ladle under vacuum.
The favourable degassing conditions result in extremely low hydrogen and oxygen contents. At the same time the nitrogen level is reduced considerably. With the elimination of deleterious gases the cleanness of the steel is improved. Teeming of the steel is carried out in air or in a shrouded atmosphere without appreciable absorption of gases. During degassing analytical corrections can be carried out by additions of deoxidation and alloy materials. Features of this process are savings in alloys and achievement of the desired properties in the steel grades produced.

Special features

- Extremely low hydrogen level
- Rapid oxygen removal by vacuum carbon deoxidation
- Vacuum decarburisation down to less than 0.004 % C.
- Achievement of tight analysis tolerances
- Low investment costs
- Simple equipment handling.

In line with the BV "building-block" system the plant can be adapted for ladle degassing and ladle to ingot stream degassing and can be converted to a VOD (Vacuum oxygen decarburisation) installation.



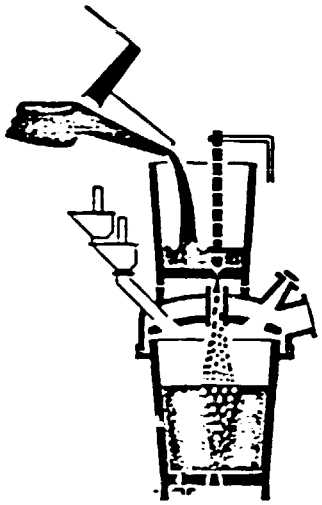
BV-ladle to mould stream degassing

The steel is teemed directly from ladle into the mould under vacuum. This method is particularly applicable for the production of heavy forging ingots. Steel from one or from several furnaces can be brought together and teemed in vacuum under the same advantageous conditions.
The favourable degassing environment of the BV-ladle to mould stream degassing process results in the lowest hydrogen levels which can be achieved technologically.

Special features

- Extremely low hydrogen content down to less than 1 p.p.m.
- Avoidance of macro- and micro-inclusions
- Normal tap-temperature
- Commercial production of the largest forging ingots
- Ingot weights from 5 t to 550 t
- No need to remove hydrogen by annealing.

In line with the "building-block" system of the BV-stream degassing process the above plant can be used for ladle to ladle stream degassing and for simple ladle degassing and can be converted to a vacuum oxygen decarburisation installation.



BV-tap degassing

This variation of the BV-stream degassing process is normally used in electric arc furnace shops where space is at a premium. The degassing treatment is carried out during the tapping of the electric arc furnace.
Here again the favourable stream degassing conditions result in low hydrogen, oxygen and nitrogen contents and in an improvement of cleanness.
The teeming of the degassed ladle is carried out in atmosphere or with inert gas shrouding, with neglible gas pick-up from the atmosphere.

Special features

- Low hydrogen levels
- Rapid oxygen removal by vacuum carbon deoxidation
- Vacuum decarburisation down to less than 0.004 % C.
- Achievement of tight analysis tolerances
- Short distances between operations
- Low investment costs
- Simple equipment.

DH-process

The DH-vacuum degassing process is one of the batch type processes.
The liquid steel is treated in a vacuum vessel via a single nozzle. The cast to be treated flows from the ladle into the treatment vessel where a vigorous reaction takes place exposing a large liquid surface area to the vacuum. The degassed portion of the steel is returned to the ladle with considerable momentum. The sequence is repeated rapidly until the total ladle contents is degassed. The teeming of the degassed steel is carried out in air or with inert gas shrouding without appreciable pick-up of gases from the atmosphere.
This process is independent of freeboard in the ladle and virtually independent of the slag layer from the furnace. It is, therefore, an ideal ladle metallurgical tool for secondary steelmaking. The evolved practices lead to best possible cleanness level and lowest carbon contents. This type of plant is particularly suitable for works with high tonnage throughput.

Special features

- Rationalisation of steel plant production
- Effective hydrogen reduction
- Rapid oxygen removal by vacuum carbon deoxidation
- Vacuum decarburisation to levels as low as 0 002 % C.
- No need to tap slag free from furnace
- Short treatment times
- Independent of free-board in ladle
- Low temperature losses
- Achievement of narrow chemical analysis and temperature ranges
- High recovery yields – with varying amounts of alloy additions made during the vacuum metallurgical treatment
- Accurate recarburisation under vacuum
- Effective mixing
- Thermal homogenisation
- Excellent separation of non-metallic inclusions leading to highest degree of cleanness
- Good refractory performance.

The following process variations are available:
DH-process with argon injection,
DH-process with oxygen blowing

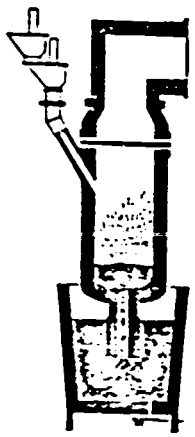
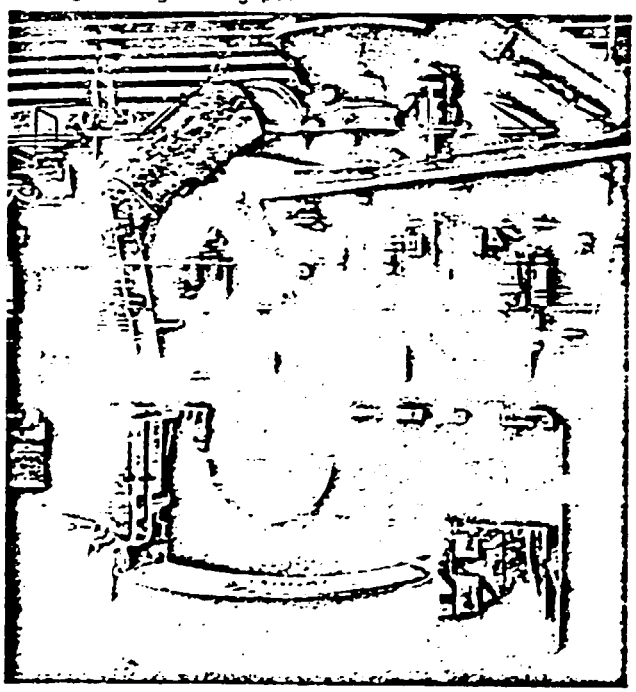
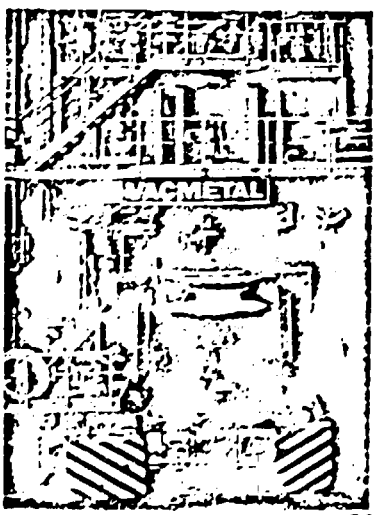


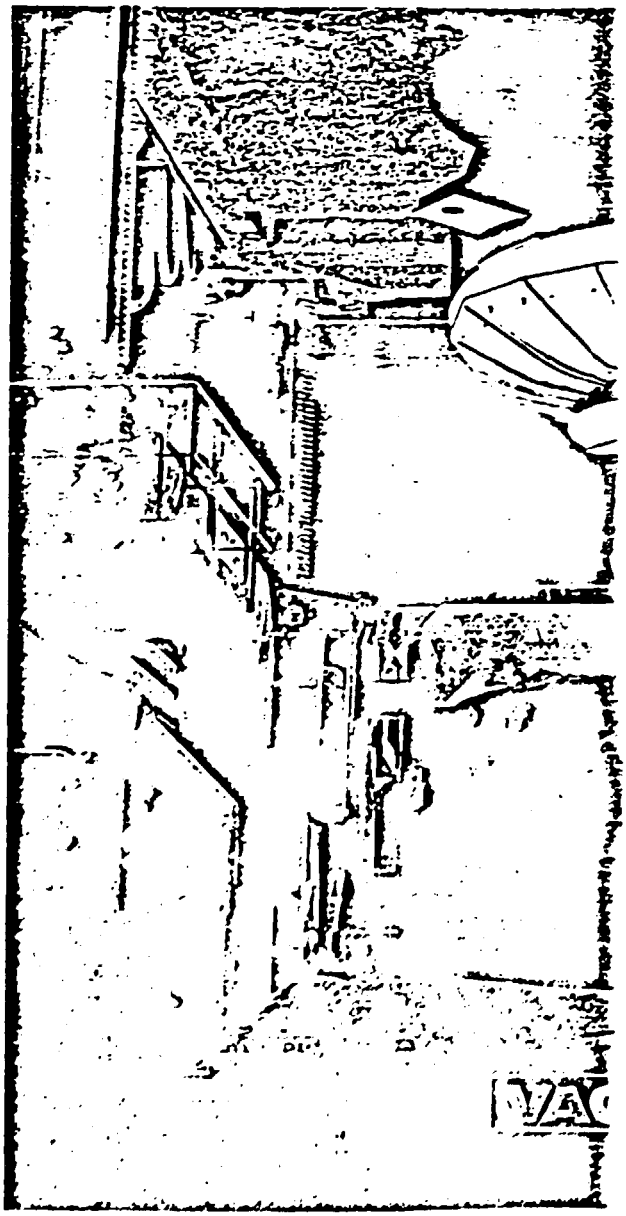
FIGURE 15



180 t DH-vacuum plant at the Phoenix Works of Hoesch Werke AG



DH-vacuum plant for 80 t casts



Vacuum circulation process

The vacuum circulation process represents another type of batch operation. Compared with the DH-process this type of plant uses two nozzles. The liquid steel is induced into the vacuum vessel by injecting argon into one of the nozzles. The dissolved gases and argon are then released in the vacuum. The treated steel returns continuously to the ladle via the other nozzle. The teeming of the degassed steel is carried out in air or with inert gas shrouding without appreciable pick-up of gases from the atmosphere.

Special features

- Rationalisation of steel plant production
- Effective hydrogen reduction
- Rapid oxygen removal by vacuum carbon deoxidation
- Vacuum decarburisation to lowest values
- No need to tap slag free from furnace
- Short treatment times
- Independent of free-board in ladle
- Low temperature losses
- Achievement of narrow chemical analysis and temperature ranges
- High recovery yields with varying amounts of alloy additions made during the vacuum metallurgical treatment
- Effective mixing
- Thermal homogenisation
- Excellent separation of non-metallic inclusions
- Good refractory performance

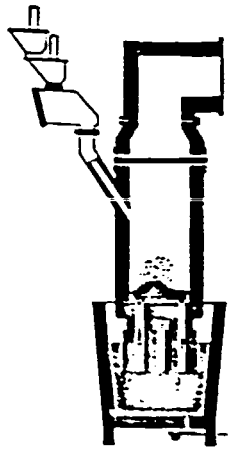
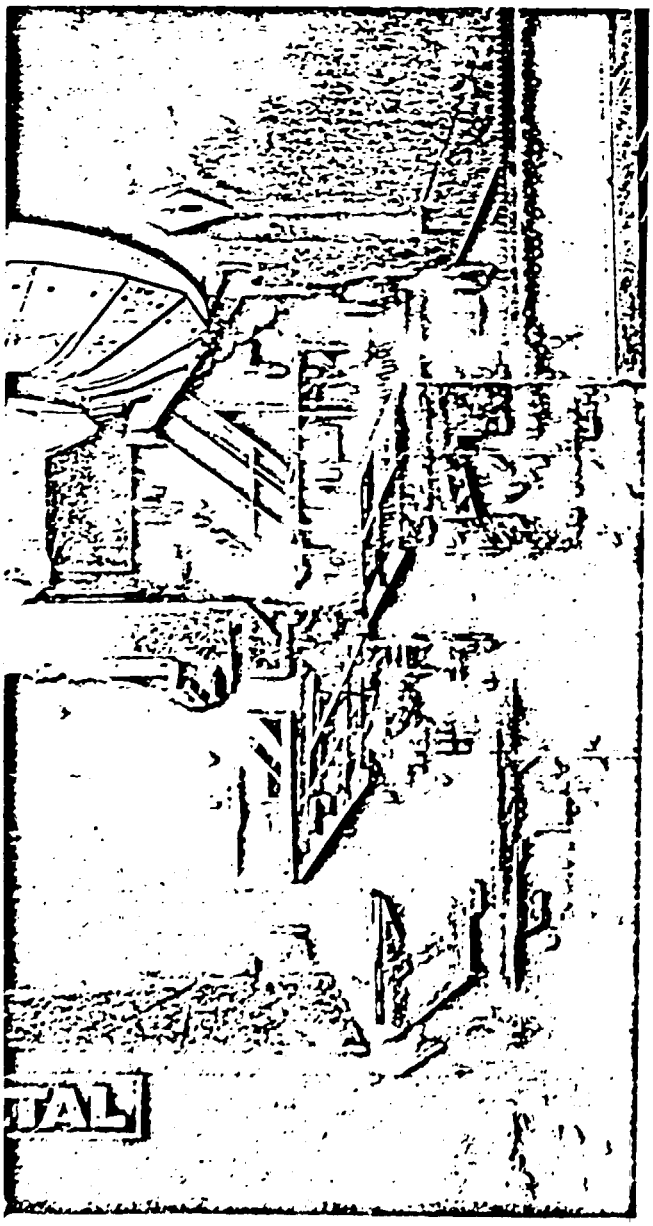
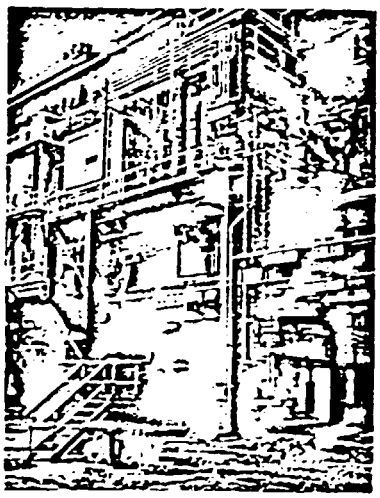


FIGURE 16

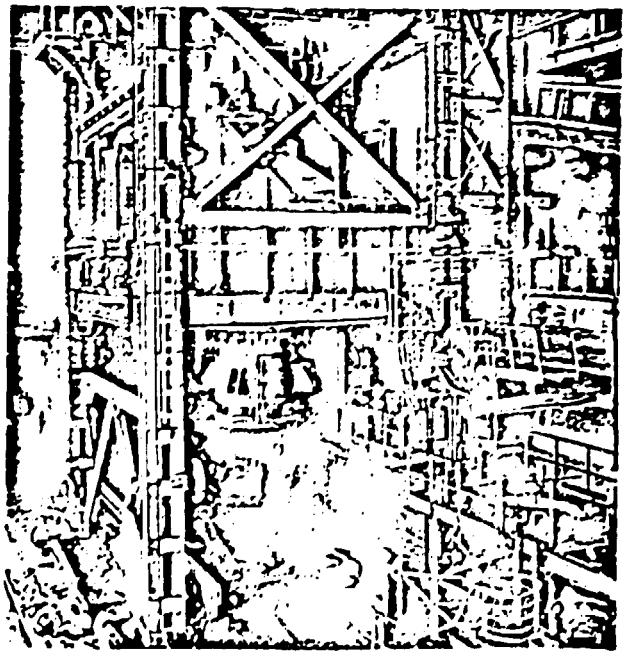


300 t DH-vacuum plant



Vacuum circulation plant for 100 t casts at Ugine Aciers in France

100 t Vacuum circulation plant at Usiminas in Ipatinga, Brazil



Desulphurisation

Pig Iron Desulphurisation

Lance injection with mixtures of CaC_2, Mg, Mg/CaC_2 or CaO/CF_2. This in combination with the Hoesch-deslagging process.

Special features

- Important tool of ladle-metallurgy
- Cost-effective desulphurisation compounds
- Reduction from high initial S contents
- Final sulphur level less than 10 ppm
- Simple equipment
- Low investment costs
- Efficient deslagging in shortest possible time
- Low iron losses

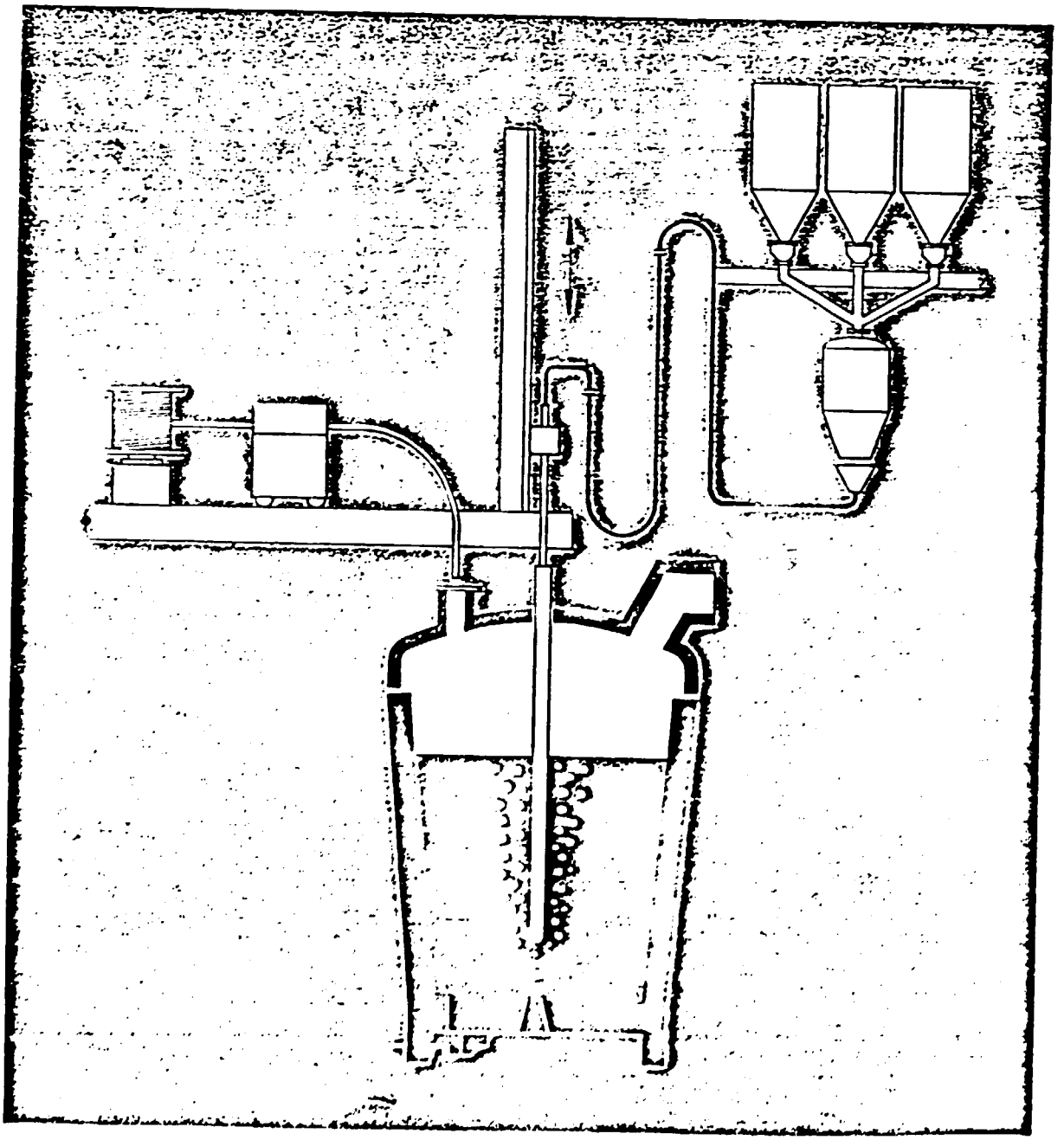
Steel Desulphurisation

The desulphurisation of liquid steel is achieved by either lance injection or cored wire feeding of calcium bearing compounds or with the additional lime together with intensive argon stirring.
Other applications of this type of plant are analysis trimming and inclusion modification by means of injection or cored wire additions of alloying compounds.

Special features

- Significant role in secondary steelmaking
- Simple equipment
- Low investment costs
- Final S contents less than 20 ppm
- Alloying under inert gas shrouding – good recovery of alloying elements
- Excellent separation of non-metallic inclusions
- Cleanness improvement
- Inclusion-modification

FIGURE 17



CAS/CAS-OB and CAB Processes

These processes are applied in secondary steelmaking for the treatment of non-hydrogen sensitive steels, for which vacuum treatment is not essential.

CAS

(Composition Adjustment by Sealed Argon Bubbling Process)

Deoxidation reagents and alloying compounds are added to the liquid steel under exclusion of the atmosphere within a partially immersed bell shaped hood.

Special features

- Alloying under exclusion of air
- Good recovery of alloying elements
- Achievement of tight analysis limits
- Good separation of non-metallic inclusions
- Good degree of cleanness from oxides
- Short treatment times, low temperature losses
- Low investment and running costs

CAS-OB

(Composition Adjustment by Sealed Argon Bubbling Process and Oxygen Blowing)

This modification offers the additional facility to the CAS process to reheat the liquid steel by means of an oxygen lance. Heating rates from 5 °C – 15 °C / min. are possible.

Special features

- Temperature correction of the ladle content
- Avoidance of return casts due to low temperature
- Alloying under exclusion of air
- Good recovery of alloying elements
- Achievement of tight analysis limits
- Good separation of non-metallic inclusions
- Good degree of cleanness from oxides
- Short treatment times, low temperature losses
- Low investment and running costs

CAB

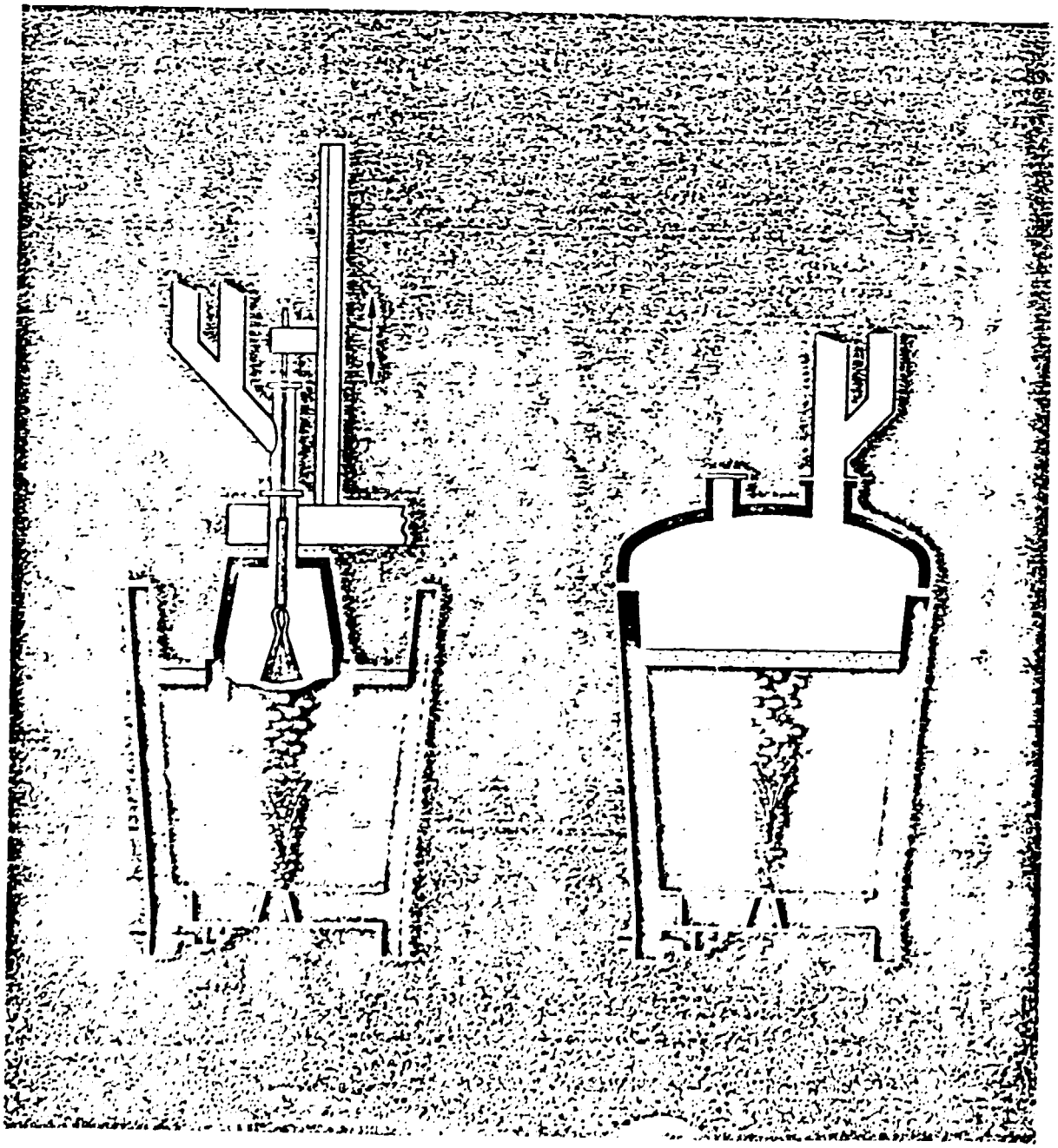
("Capped" Argon Bubbling Process)

This inert gas bubbling process leads to the improvement of oxide cleanness under the exclusion of air of liquid steels in sandslung or semi-silica lined ladles.

Special features

- Good separation of non-metallic inclusions
- Improvement in cleanness
- Improvement of aluminium recovery
- Exact achievement of casting temperature
- Short treatement times

FIGURE 18



To keep up with the increasing demands of super high grade steels, the development of ladle refining processes has been relentlessly pursued. The aim of these ladle refining processes is to efficiently minimize/remove non-metallic inclusions and impurities such as sulphur, phosphorus, oxygen, nitrogen and hydrogen. As a result, the proportion of total converter (BOF/LF) steel production undergoing secondary refining and ladle metallurgy since 1988 has amounted to over 70% in Japan. Additionally, by optimizing the continuation of various types of ladle refining, it has been rendered possible to effectively reduce impurities of levels less than 20 ppm of carbon, 10 ppm of phosphorus, 5 ppm of sulphur and 8 ppm of oxygen.

Tundish Metallurgy

In continuous casting processes, the quality of steel cast is affected by the tundish. Hence various measures have been applied to prevent molten steel streams from reoxidizing and to make non-metallic inclusions float up and to stabilize the casting temperatures. To prevent reoxidation of molten steel during teeming, a long nozzle is placed between the ladle and the tundish over the molted steel. Additionally, a slag detector is attached to the ladle to prevent slag carry over into the tundish. The tundish is filled with argon gas thereby preventing steel reoxidation. Tundish dams control the flow of molted steel and make the impurities float up. In the tundish, filters remove the impurities contained in the molten steel and minute bubbles of inert gas are injected into the tundish to promote the floating out of the impurities.

Figure 19 shows the Tundish refining for upgrading steel purity.

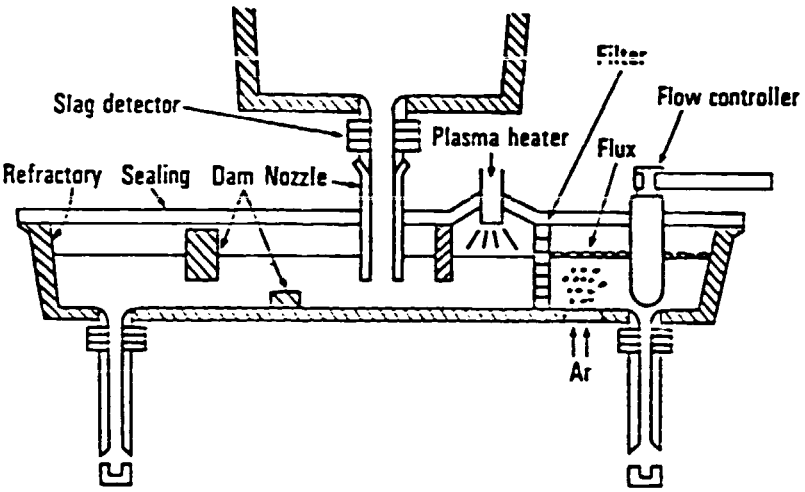


Figure 19 - Tundish Refining for Improving Steel Purity

Controlled Rolling Technology

Strength, toughness, high yield strength and weldability are qualities which are basic to steel including steel for welded construction. However, more serious are the service conditions, the tougher the material requirements become. To keep up with these demands, addition of expensive elements such as nickel, annealing in the off-line process and heat treatments such as quenching and tempering have been employed. These steps, however, increase production costs, production time, and lower productivity.

The remedy to these problems, Thermo Mechanical Control Process (TMCP) was developed. This is designed to reduce the alloying elements added through optimum controlled rolling and controlled cooling which impart high toughness and high strength and results in significant lowering of production costs and energy consumption. These measures have borne fruit in the production of high toughness and high strength steel (400,000 tons) which was used for the large diameter steel pipe for the Trans-Alaska oil pipe line and has led on to other

applications as well. These controlled and accelerated cooling systems are now extensively employed in Japan, the USA and other countries.

A variety of high strength formable steel sheets with transformation-induced plasticity (TRIP) characteristics, which will facilitate the use of thinner material for auto bodies, have been developed for mass production/consumption. It is claimed that these TRIP steels have been able to compete successfully with aluminum alloys, plastics and composites in the weight reduction areas. Vibration damping steel sheets for automotive applications, wherein steel sheets are being produced by rolling together a thick layer of visco-elastic polymer sandwiched between two outer steel sheets, have also been developed for superior performance reliability of the auto bodies. Apart from automotive applications, these vibration damping steels are finding other useful consumer applications.

In 1965, only 1% of the world steel was continuously cast. Today this figure is 60%. Over 82% of all steel produced is now continuously cast in the western world. In conventional slab casting, slabs are cast 200-250 mm thick and hot rolled in a number of steps to the final strip gauges. Thin slab casting and thin strip casting are now being developed. In this strip casting, steel is cast even closer to finished product size from 1 to 6 mm. A major problem is that high casting speeds are necessary if reasonable strip production rates are to be achieved. Voest-Alpine and Allegheny Ludlum have joined to market a technology for casting strip as thin as 3 mm. A prototype is expected to be operational by 1993.

Another method of thin strip casting is spray forming, in which atomized molted metal is sprayed on the substrate metal strip and then compacted; it is also known as the Osprey process or the Swansea process.

These developments are now dynamically changing steel production, rolling and furnishing operations and will lead the steel industry to high productivity, lower production costs and highest possible yield figures.

Intelligent Processing and Expert System, Automation and Computerized Operation of the Steel Industry

A large number of Expert Intelligence Systems are now comprehensively applied in the steel industry. The Japanese Steel Industry initiated intelligent processing systems in the mid-eighties and today it is applying "artificial intelligence", A1 systems for multiple operations in the Japanese Steel Industry is as depicted in Figure 20.

On a larger scale, AISI in the USA is initiating a Joint Industry-Government Research Project to develop Intelligent Processing Systems that will permit the steel industry to control the steel making processes based on the ability of a super computer to instantly sense the changes in the chemistry of the hot metal and steel, beginning from the blast furnace to steel production and to the rolling and finishing lines. Alerted with the sensor data, the computerized system then urgently adjusts the process variables and reschedules the operations. Sensors that report the real time conditions will be playing a much greater role in the intelligence processing systems for the steel industry. Special efforts are directed to develop specific types of sensors for use in Multiple Expert Systems including super-intelligent sensors. The umbrella term for the technology dedicated to smartening up the computers is the artificial intelligence which mimic humans experts.

United States companies that reportedly have Artificial Intelligence Systems in operation and/or in advanced development stages, include the USS Division of the USX Corporation, Bethlehem Steel Corporation, LTV Steel Company, ARMCO, the Timken Company and the Inland Steel Company. The A1 system most significant today is Scheduling. For improved scheduling can improve productivity while greatly reducing inventory holding costs. At one rolling mill, only 20% of the steel producing on any given day was ready to be shipped to the customer and all the rest was inventorized - an expensive and costly practice and costly warehousing. A1 Scheduling Systems which make a sizeable dent in this inventory can pay for themselves many times over. Several United States firms and most Japanese steel firms have

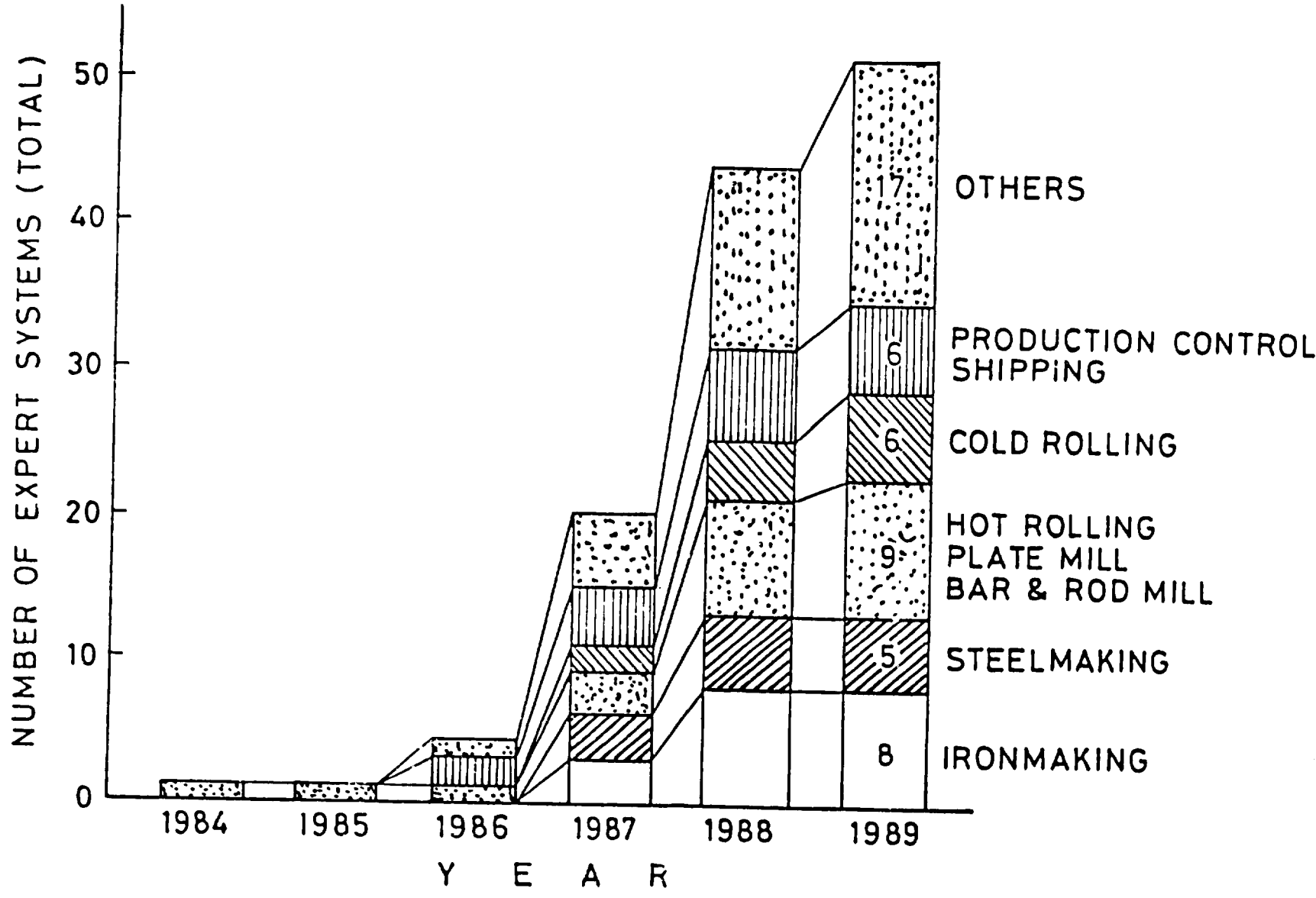
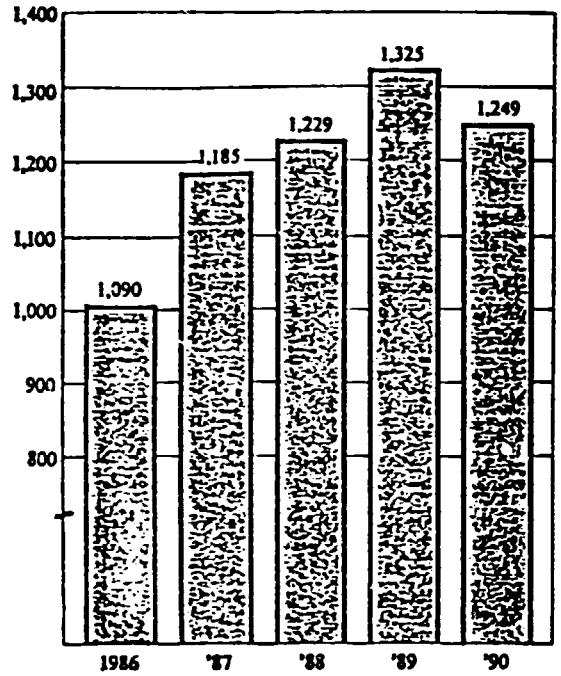
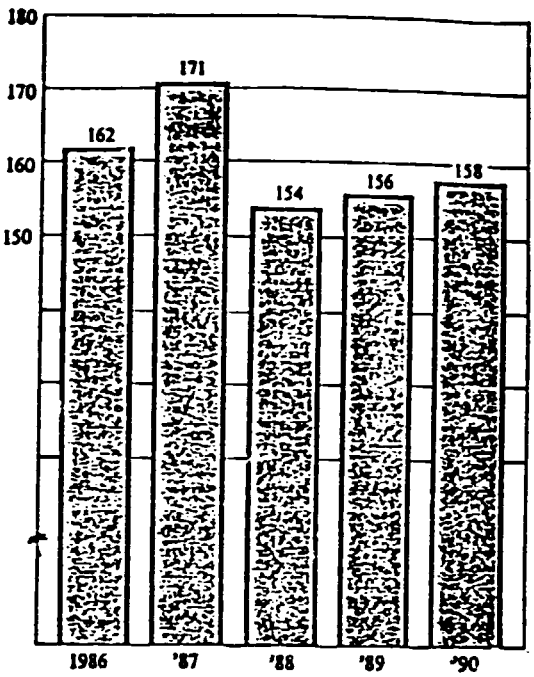


FIG. 20 PROGRESS OF EXPERT SYSTEMS IN THE JAPANESE STEEL INDUSTRY

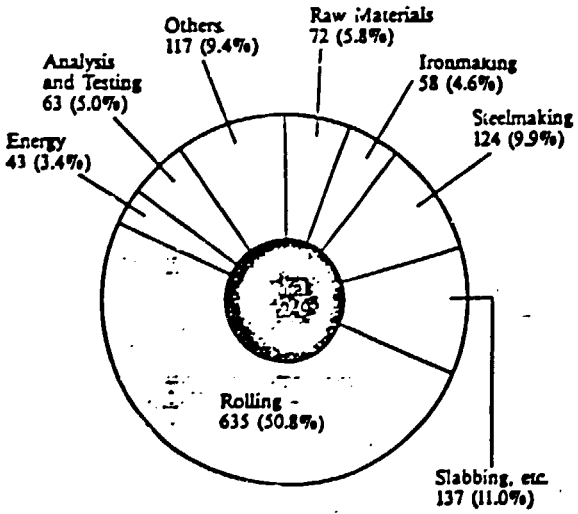
Number of Process Computers Installed



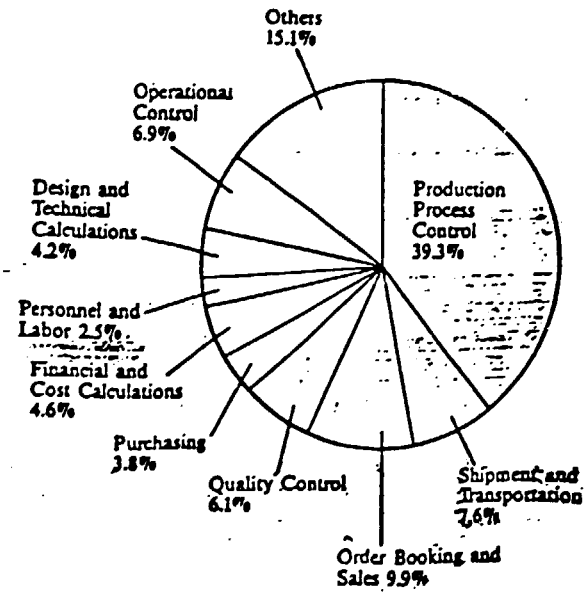
Number of Business Computers Installed



Process Computers Introduced, by Process *(as of January 1990)*



Use of Business Computers by Type of Operation *(as of January 1990)*



Note: Of all processes, rolling accounts for 54% of the process computers used in the steel industry.

Figure 21

scheduling systems in operation. USS has developed a plate mill scheduling thereby assisting the plate mill schedulers to generate, evaluate, simulate and modify schedules to balance a number of factors such as the slab thickness, plate gauge, the finishing process, the work roll conditions and others. Upon receiving the data from a corporate mainframe computer, a personal computer develops a program that allows for the addition, deletion and resequencing of the slabs to help create an optimal production schedule. The Japanese steel industry started field tests on A1 for the purpose of production process automation in 1983. Niffon Steel has applied expert systems for iron making, hot rolling, steel making, transportation, power plant regulations, surface treatments, bar and rod operations, cold rolling, plate rolling, etc. Figure 21 shows the current situation in Japan.

The Japanese led the way in "Just in Time" inventory management advocated by W. E. Deming, an American statistician and management expert whose ideas about quality control helped revolutionize Japanese manufacturing industries after World War II. Deming was not heeded in the USA until the last decade when Deming's ideas and practices were imported/reimported from Japan to the United States. Many United States companies had to learn some painful lessons before they came to believe in Japanese methodology and applied it fully to save a crisis situation amounting to going out of business. "Just in Time" defines and makes possible other technologies such a KANBAN, a system of organizing the work place, continuous quality improvement and reduced times for making product and technology changes. Other Japanese technologies include employee involvement in decision making and responsibility for quality and high productivity. The benefits are incredible. If you do not have to carry so much inventory, you do not have to pay interest on the funds blocked in the inventory, nor does one have to build warehousing to store the inventory. Associated with the "Just in Time" technique, is employee commitment. Production flow is simplified and problems

are detected "Just in Time". "Just in Time" technologies advocated by an American are central to the Japanese and have now been adopted by the United States industries albeit much delayed.

Pohang Steel - South Korea

The Pohang Iron and Steel Company's (POSCO) main corporate system allows executives to monitor any stage of the steel production process, from raw materials on the dock to the temperature of the blast furnace in the steel plant. To accomplish these tasks, the computer system automatically updates 70% of the data used in tracking some 60,000 items for cost control. At the head office in Pohang, POSCO has a FACOM M380Q for general administration while the steel plant itself runs a FACOM 380R for production/process control. A FACOM M360 is used for sales and marketing. The new Kwangyang works of POSCO has an IBM 3090-18E, a 3090 and a 3081. The mainframes in Kwangyang, Pohang and Seoul are connected with a 4800 bits per second link. Nearly 600 PC's are connected to the mainframe via LAN links. Production is controlled by a Digital VAX8650 at Pohang and an IBM 3500 at Kwangyang. A total of 79 computers monitor and control all vital stages of the production processes and coordinate the flow of materials from the start to the end of the steel making process. UPI Computer's steel making process control software is used. POSCO has spent an average of 0.11% of its sales revenue on the IS over the years of 1986 through 1989 which is about $2.47 for a ton of steel produced at the Pohang works. POSCO maintains that the expenditures are about equal to Nippon Steel and other top Japanese producers who are POSCO's closest competitors.

In the United States, the US steel makers are upgrading productivity and efficiency through computer-integrated manufacturing (CIM) in which the computers determine optimum material flow through refining and processing facilities and track steel down through each operation. With CIM based tracking technology, mills can better control costs, reduce in-plant

inventory and cut the amount of material handling chores they must perform along the way, all productivity enhancers.

Geneva Steel (US)

Geneva Steel in Vineyard, Utah (USA) plans to install a continuous casting facility to produce thick slabs and also thin slabs. Geneva is the first U.S. steel producer to announce the installation of a thin slab caster at an integrated steel plant. The new caster will be designed to produce conventional slabs 10" thick to support Geneva's existing product mix. In a "quick change" schedule, the machine will convert from a thick slab to a 2" thin slab. The casting machine will be connected to the existing rolling mill to allow direct rolling of the slabs without the need for reheating unlike NUCOR at its Crawfordsville, Indiana plant in the United States. Geneva Steel expects that the combined Q-BOP, caster and direct rolling technologies will improve finished product yield, reduce enery and labor costs, increase throughput capacity and improve metallurgical and surface quality of the mill's finished product mix.

The future product mix of the steel industry will have to be oriented toward the production of special and super grades of steel of super purity. The acceptable limits of metalloids in these super grades of steel will be very low, e.g., for line-pipe steel, sulphur level is around 0.005% and phosphours lower than 0.002%. By the year 2000 AD, it is expected that the sulphur may be as low as 0.0015%.

All such super refinements will be met by specialized emerging steel technolgoes, aided by computerized process control at each and every level and full use of automation and instrumental quality control measures which will pay good dividends.

Kawasaki has been able to capitalize their knowledge of the steel industry. CIM, in building management system for a greenfield site like KSE Finsider/Siderbras joint venture, Companhia Siderurgica de Tubarao, 500 KW northeast of Rio de Janeiro, in Brazil. Information dissemination systems is a sector that is growing faster than the steel industry.

Micro-alloyed HSLA Steels

In the last 2-3 decades, micro-alloyed high strength low alloy steels (HSLA) are preferred for a wide variety of structural applications Dual Phase (DP) are special class of HSLA sheet steel characterized by high strength, durability and formability. The properties make them attractive in automative applications as complex shaped and flat rolled products and in line pipe applications at low temperatures. In contrast, TRIP (transformation induced plasticity) steel constitute a new class of highly alloyed, ultra high strength, meta stable austenitic steels with greatly increased durability and toughness. As a result, they find applications as special flat rolled products and wires, etc.

Conclusions

Developing countries have to progressively apply the latest technological innovations to their steel industry such as computerized contolled operations, thin slab casting, Energy optimized furnace operations, secondary steel making and ladle metallurgy, continuous casting, etc. to ensure both qualitative and quantitative upgrading Energy consumption per ton of steelmade will have to be reduced to conform to international figures.

Energy consumption in the Japanese steel industry (1980-1990) and it comparison with other steel producing countries are illustrated in Figures 22 and 23.

Figure 24 depicts the continuous casting rates of major steel producing countries and shows that South Korea, a developing country, has a continuous casting rate/ratio higher than the USSR and the United States. Other developing countries can well follow and emulate the highly progressive and efficient steel industry in South Korea today while in 1966-1967, South Korea had practically no steel industry at all worth talking about.

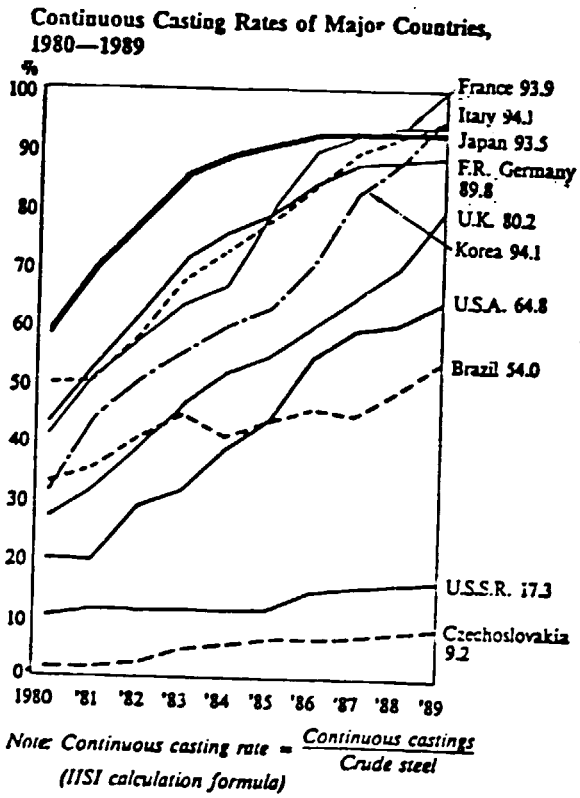
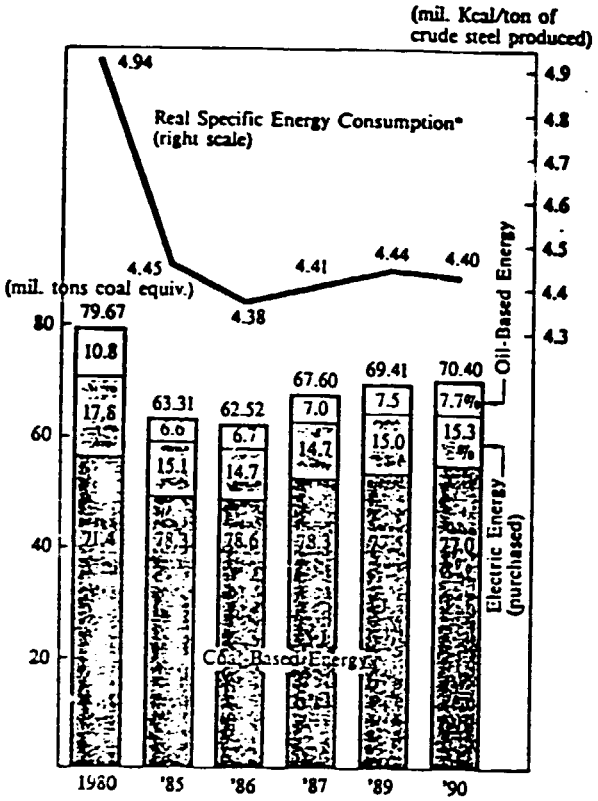


Figure 24

Since the energy crisis of 1970, U.S. steel makers have cut their energy consumption by over 35%. As electric power, natural gas, coal and other fuels rival labor as the most expensive component for producing a ton of steel, their consumption has been cut down considerably. The Japanese steel making have led the way in this respect since Japan had to import almost all of its oil or fuel supplies. In 1990, two-thirds of all steel made in the United States has been continuously cast while in 1980; it was only one-third. Japan now links 94% of its steel as continuously cast. In Indiana, which produces over half of all steel produced in the United

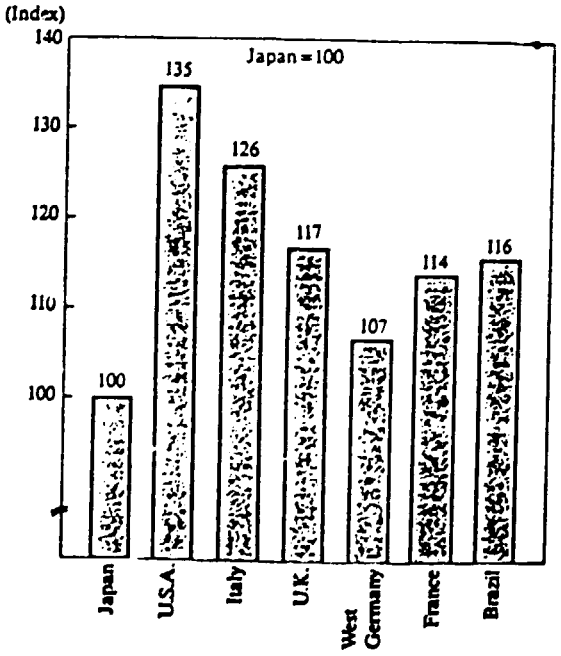
Energy Consumption by the Steel Industry, 1980—1990



Note: These figures represent energy consumption by the steel industry, excluding the coke-making and ferroalloy-producing sectors.
**Total energy consumption by the steel industry divided by crude steel production.*

Figure 22

Real Specific Energy Consumption in Major Steelmaking Countries, 1989



Source: estimated from IISI data.

Figure 23

States, all the integrated steel plants like LTV Steel Co., Inland Steel, Bethlehem Steel and USC Corporation's Steel Division or also the Mini Steel producer NUCOR, Crawfordsville, Indiana handle the steel through continuous casters.

Table 11 depicts per capita apparant steel consumption for different countries and shows the disparity between developing countries and the developed world while Table 12 shows the crude steel production by major steel producing countries.

Figure 25 graphically illustrates the crude steel production country wise from 1980 through 1990 and shows that while the USSR has the highest steel production in the world and yet it has the lowest continuous casting rate/ratio in the world with the exception of Czechoslovakia.

Figure 26 depicts the reported steel production costs for different countries from 1980 through 1990.

A technical document of this type under preparation cannot claim to have said the last words on the complex subject of the iron and steel industry which is worldwide full of anamolies, contrasting performances and output, and different technologies; these technologies are being steadily upgraded, pruned and conditioned to suit individual countries. The steel technology is undergoing dynamic growth and pragmatic applications. Such technological developments and emerging processes have to be judiciously applied in the developing world.

The point to be emphasized is that techno-economic study of the emerging technologies and processes presents today a fast and vastly changing spectrum that can by no means be accepted universally for all countries developing and developed and for all times to come. And that is where UNIDO's role is of strategic and paramount importance and value to the developing countries through formulating and implementing technical assistance programs and projects with a view to enable developing countries to select and appropriately apply the most judicious, optimum and appropriate technology to their steel industry.

Per-Capita Apparent Crude Steel Consumption

(kilograms crude steel)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
France	374.2	322.3	315.7	279.5	282.0	268.5	262.2	266.4	303.9	312.8
F.R. Germany	565.2	528.6	452.9	492.4	507.6	505.1	501.5	476.5	577.7	576.1
Spain	246.7	216.3	239.1	195.6	183.2	174.4	228.5	231.6	270.9	318.0
United Kingdom	285.0	285.4	269.5	260.9	253.7	253.5	261.1	263.1	306.5	304.2
E.C. Total	377.8	337.6	324.4	315.8	320.1	315.8	323.7	319.4	375.6	386.2
United States	502.4	560.4	362.5	402.4	471.4	441.3	394.4	416.0	449.8	412.2
Japan	676.4	604.6	586.8	550.2	619.6	607.7	575.7	619.7	706.4	753.8
Brazil	117.9	97.2	83.6	66.1	80.5	88.5	104.9	105.9	81.2	84.5
Mexico	148.7	159.6	111.9	84.0	95.5	98.0	83.1	79.9	84.2	86.1
Venezuela	186.3	166.5	186.1	103.0	124.5	102.2	147.4	176.3	184.9	138.2
Total Latin America	103.1	93.6	79.2	62.5	72.6	72.9	78.3	81.1	73.9	71.3
Total Africa	21.6	22.1	19.7	19.0	18.6	20.7	22.6	17.7	16.8	15.6
Iran	91.8	69.6	100.0	133.7	101.3	127.7	87.9	109.7	86.1	95.6
Iraq	146.3	106.6	80.4	80.7	58.2	63.6	28.2	40.7	38.4	48.7
Saudi Arabia	335.7	376.5	589.9	516.1	425.4	364.5	233.1	208.6	228.0	186.5
Total Middle East	149.1	138.6	173.0	184.1	163.5	162.1	103.5	103.8	95.0	95.0
India	16.2	20.3	19.7	16.1	18.9	19.2	20.0	22.6	23.9	24.7
Republic of Korea	160.0	193.2	194.0	215.9	262.1	275.5	293.2	357.6	369.1	418.6
Taiwan (R.O.C.)	355.4	306.7	274.9	308.0	320.1	328.0	402.7	477.9	584.6	701.0
Thailand	42.8	38.8	50.4	62.2	45.9	53.6	44.2	50.4	58.3	64.0
Total Asia	29.2	31.8	32.5	31.8	32.7	33.2	35.0	39.9	43.1	47.0
Czechoslovakia	710.9	738.5	728.4	725.1	708.2	717.0	720.4	707.4	693.9	704.4
Poland	539.8	428.1	397.3	405.3	413.3	405.2	426.7	420.1	409.4	358.1
Romania	552.8	520.7	525.9	492.4	523.8	493.4	532.3	550.3	523.2	527.3
U.S.S.R. (E)	566.1	563.5	556.7	578.2	579.4	566.3	576.4	575.7	580.3	581.8
China	43.6	39.0	40.2	50.6	58.1	68.3	72.1	66.3	63.6	63.0
World Total	162.1	157.2	142.4	142.8	151.0	149.4	147.6	148.0	153.0	151.1

E = estimate

Table 11

Crude Steel Production by Major Steel-Producing Countries, 1990

(million metric tons)

Rank	Country	Tonnage
1	U.S.S.R.	153.9
2	Japan	110.3
3	United States	88.7
4	China	67.2
5	F.R. Germany	38.4
6	Italy	25.4
7	Republic of Korea	23.1
8	Brazil	20.6
9	France	19.0
10	United Kingdom	17.9
11	India	14.9
12	Czechoslovakia	14.8

Table 12

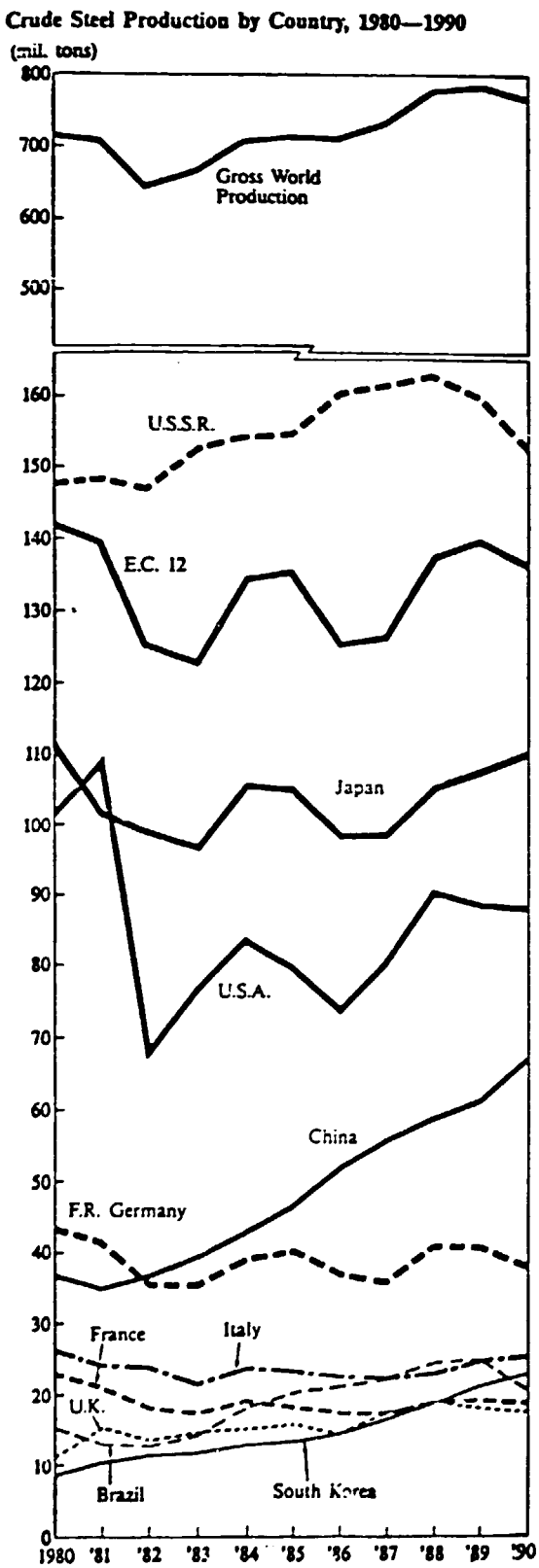


Figure 24

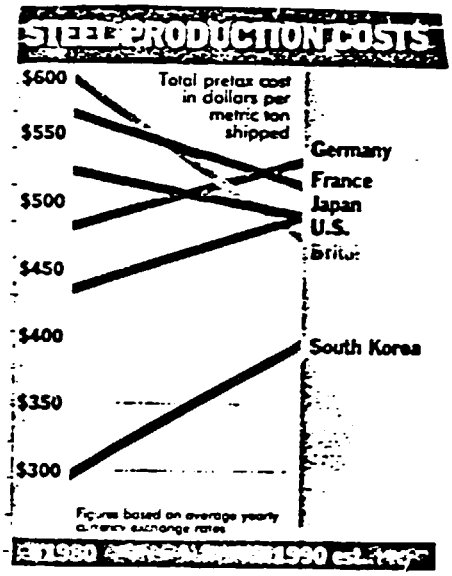


Figure 25

In conclusion, a mention is made of a reported scenario of the steel industry in the year 2020 AD when it is claimed there would be radical changes in store for the steel industry.

Twenty years into the next century, radical changes will take palce in the steel industry, e.g., the following:

a. Direct steel making - from raw materials to liquid steel

b. Near net shaped steel product mix

c. Ultra modern continuous finishing of the finished product-mix

d. Further downstream integration and assembly of finished products

By 2020 AD, customers will be demanding products that are undreamt of today with perfect uniformity, chemistry, surface finish, strength to weight raio and corrosion resistance. Injection moulding and rapid solidification would be employed using new high temperature ceramics. Electro-magnetic liquid shape forming technology will replace the "spray" and "freeze" operation of rolling mills.

Computerization will take over decision making from memory about variables such as temperatures, gauges, shapes, surface quality, etc.

By 2020 AD, the steel industry will be environmentally friendly with very little wastages and discards. All inclusive recycling of the steel plant wastes and by-products will be the order of the day resulting not only in producing "clean" steel but also ensuring "cleaner" environments.

The developed countries and those developing will have to pool their resources of raw materials, technology updating and transfer, joint ventures in multiple fields of research and development and industry, etc. If these goals are to be achieved, UNIDO will have to play a leading part to continuously achieve the above goals and objectives.

Acknowledgements

In accordance with the "Terms of Reference" covering the "Special Service Agreement" entered into between UNIDO and the writer, this paper/document is based essentially on the

deliberations of the Technical Sessions on "Emerging Technologies of the Steel Industry - New Materials and Steel Product-Mix", held during the Materials Week of the ASM Inernational at Cincinnati (21-24, October, 91) and which had been organized by the writer as the Program Organizer for ASM-International, aligned of course to the requirements of UNIDO for technical assistance to the developing countries, based on the writer's experience and observations Bibliographic References to the Exhibitors and the Exhibitions held during 22 to 24 October, 1991 of the Materials Week of ASM International are contained in Appendices A and B of this document/paper.

The writer wishes to thank UNIDO for facilitating the expression of his views and technical data presented herewith. ASM has also organized during the Materials Week, the Materials Exposition and Steel Treatment Exhibition. The list of exhibitors for the Materials Exhibition along with a brief outline of the Exhibits are shown in Appendix A.

The list of Exhibitors for the Heat Treatment Exhibition along with a brief outline of the Exhibits are shown in Appendix B.

MATERIALS EXPOSITION EXHIBITORS
(as of 9/20/91)

1000 Holometrix, Inc.
1001 Nano Instruments, Inc.
1002 Anatech Ltd.
1004 American Welding Institute
1005 Textron Specialty Materials
1006 Title III Program Office
1201 Codonics, Inc.
1203 Philips Electronic Instruments Co.
1205 A.J. Tuck Company
1209 Metalworking Technology, Inc.
1210 MMA Laboratories
1216 Leica Inc.
1217 White Engineering
1220 Anter Laboratories, Inc.
1221 New Mexico Advanced Materials and Manufacturing Technology Consortium
1223 Baikowski International
1225 American Welding Society
1228 Buehler Ltd.
1229 DuPont Co.
1231 David Sarnoff Research Center
1233 Theta Industries Inc.
1234 ABB Autoclave Systems
1303 VDM Technologies Corp.
1309 Technology For Energy Corp.
1310 South Bay Technology
1311 Crystalite Corp.
1312 Noran Instruments, Inc.
1313 MQS Inspection Inc.
1314 Carl Zeiss, Inc.
1315 SATEC Systems, Inc.
1320 Mar-Test Inc.
1321 Union Carbide Advanced Ceramics
1322 Ricerca, Inc.
1323 Materials Analytical Services, Inc.
1326 Metal Samples Co., Inc.
1327 The Electrofuel Mfg. Co. Ltd.
1328 Spang Specialty Metals
1329 E.A. Fischione Instruments, Inc.
1330 Kaiser Rollmet
1331 Princeton Gamma-Tech, Inc.
1334 Instron Corporation
1404 Thermo Electron/Tecomet
1408 Nikon Inc., Instrument Group
1409 Schenck Pegasus Corp.
1413 Sherritt Gordon Limited
1414 J.W. Lemmens, Inc.
1416 Poco Graphite, Inc.
1417 Charles C. Kawin Co.
1420 National Forge Company
1421 Unitron Inc.
1423 Orton Ceramic Foundation
1427 Ceracon, Inc.
1428 MTS Systems Corp.
1429 Questar Corp.
1431 C.C. Technologies
1432 Optra, Inc.
1433 Implant Sciences Corporation
1434 ElectroScan Corporation
1435 Haynes International, Inc.
1436 Analytical Associates, Inc.
1503 Lawrence Livermore National Laboratory
1506 Naval Research Laboratory
1509 Bowser-Morner, Inc.
1510 Martin Marietta Energy Systems
1511 Bureau of Mines/U.S. Dept. of Interior
1513 National Institute of Standards & Technology (NIST)
1515 National Institute of Standards & Technology (NIST)
1520 Ortech International
1522 Shiva Technology
1526 Battelle
1527 Charles Evans & Associates
1529 ISM Technologies, Inc.
1530 Aerobraze
1533 UES, Inc.
1534 Inco Alloys International, Inc.
1535 Struers, Inc.
1602 Penton Publishing
1608 E S Microware
1610 Orbit Search Service
1611 Ceramic Industry
1612 Copper Development Assn.
1613 SAE
1614 MPD Network/STN International
1615 Information On Demand, Inc.
1617 Dialog Information Services, Inc.
1619 ASM/Materials Information
1620 Information Handling Systems
1622 Allied-Signal
1623 Material Aid
1624 ISO Spectrum
1625 IQS, Inc.
1626 Astro Met, Inc.
1627 Olympus Corporation-Industrial Fiberoptics Div.
1630 Tensile Testing
1632 AVS Industries
1633 NewAge Industries Inc.
1634 AECL Research
1734 Vacuum Furnace Systems Corporation
1735 Geller Microanalytical Laboratory
1737 Anderson Laboratories
2101 Edison Welding Institute
2103 CWC Textron
2105 Hetherington, Inc.
2106 Micromeritics
2108 Sherry Laboratories
2110 Interlaken Technology
2111 Duffers Scientific, Inc.
2116 Leco Corporation
TT1 Process Products Corporation
TT3 Polishing Specialties Co.
TT2 Griff Machine Products Co., Inc.
TT4 Wolpert/Probat
TT5 Kellermann Manufacturing Co.
TT7 Freund Publishing House
TT8 Metron Technology
TT9 Insight Scientific Inc
TT10 S.S.B. Technologies
TT11 Metallon Engineered Material Corporation
TT12 Elmdas

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Mr. William G. Wood
Parker Corporation
Northville, MI

ABB AUTOCLAVE SYSTEMS INC. *(Columbus, Ohio)*
Booth #1234 -- features laboratory, pilot plant and production-sized hot (HIP) isostatic and cold (CIP) isostatic pressing equipment, as well as highlighting new advances in HIP technology such as: oxygen environment HIPping, workzone dilatometers, high temperature measurement systems, uniform rapid cooling (HIP Quench), and complete computer-based controls.

Also on display will be components made from silicon nitride with ABB Cerama's encapsulation/HIP technology. ABB Cerama also can provide products such as: silicon nitride milling media, ceramic mixers, or programs for development of customer products from advanced ceramic materials.

AECL RESEARCH *(Chalk River Laboratories - Chalk River, Ontario, CANADA; Whiteshell Laboratories - Pinawa, Manitoba, CANADA)*
Booth #1634 -- features Neutron Diffraction, a nondestructive technique, that can measure residual stress gradients and texture within the bulk of engineering components; Internal Friction and Surface Topography Characterization (services and custom systems); and Ionizing Radiation for curing, cross-linking and grafting of advanced composites, and for producing plastics with unique properties.

AEROBRAZE *(Cincinnati, Ohio)*
Booth #1530 -- description not available at time of printing.

A. J. TUCK COMPANY *(Brookfield, Connecticut)*
Booth #1205 -- features electroforming, a process for fabricating metal parts by electrodeposition in a plating bath over a base form or mandrel which is subsequently removed. The advantages are faithful reproduction within one micron, without shrinkage or distortion associated with other metal forming techniques. Since the mandrel is produced as an outside surface, extremely complex and accurate interior configurations can be achieved.

The process is limited to copper and nickel, but due to refined crystal structure, superior physical properties are achieved over wrought. Complete manufacturing services including design assistance, quality control to mil spec, electroforming, plating, CNC machining, soldering and assembly.

ALLIED-SIGNAL *(Morristown & Parsippany, New Jersey)*
Booth #1622 -- features advanced development materials including new high temperature ceramics. BLACKGLAS™, SPECTRA™ fibers, METGLAS™ magnetic, solder and brazing alloys, and the new HTA - High Temperature Aluminum alloys. The high temperature ceramics and BLACKGLAS have found uses in engine components. SPECTRA SHIELD composites have established wide use in ballistics protection (armor, helmets, etc.) as well as such diverse areas as sailcloth and cut resistant gloves. METGLAS foils and HTA alloys are produced using Allied's rapid solidification technology. The amorphous structure of METGLAS alloys puts them among the softest magnetic materials in existence for present and emerging applications. The same process applied to brazing and soldering alloys produces unique filler metals with more superior technical performance than conventionally produced alloys. The aluminum alloys, HTA, possess light weight, greater strength and corrosion resistance at high temperatures versus alloys presently used, most notably Alloy 8009.

AMERICAN WELDING INSTITUTE *(Knoxville, Tennessee)*
Booth #1004 -- features a non-profit organization that provides services to the welding and joining industry. Services include, but are not limited to, the following list: Equipment evaluation, quality control, customized software, mechanical testing, etallurgical analysis, onsite trouble shooting, failure analysis and specialized training development of Welding Procedure Specifications. AWI personnel will be available in the booth to discuss AWI services as well as demonstrate software developed by AWI. Software featured at the booth will include a new release of FERRITEPREDICTOR which predicts ferrite content in weld metal using the new WRC 1988 Constitution Diagram.

AMERICAN WELDING SOCIETY *(Miami, Florida)*
Booth #1225 -- features information on AWS codes, standards and specifications; technical literature; Welding Journal; Annual Convention and Show; Certified Welding Inspector program; educational seminars/conferences and membership.

ANALYTICAL ASSOCIATES, INC. *(Detroit, Michigan)*
Booth #1436 -- features complete Metal Testing Services, including (a) Chemical Analysis: determination of Major, Minor, and Trace Elements and Gases in Metals; (b) Physical Testing: Hardness & Tensile Properties, Bend Tests, Proof Loads, etc.; (c) Metallurgical Testing: Microstructures, Plating thickness, Microhardness, Grain size, Failure Analysis, etc. (d) Corrosion Testing: Salt Spray, Humidity, Intergranular Corrosion Susceptibility, etc.; (e)

Technical Photography: Regular, Micro, Macro, under visible, IR, or UV lighting; (f) Special Melting Services: Melting of Samples or experimental Alloys (up to 17 lbs) in a vacuum Induction Melting Furnace.

Analytical Associates is an A2LA accredited Laboratory (in the Chemical and Mechanical Fields of Testing, including Fastener Testing). - Expert Witness and Consultation services also available.

ANATECH LTD. *(Alexandria, Virginia)*
Booth #1002 -- features CASiDIAM™, a hard carbon coating for wear resistance and chemical inertness. HUMMERS™ for thin film deposition for research and failure analysis. AIM 2.0 ion mill for thinning samples for TEM and the IG-50, or 5cm broad beam ion source for surface modification of materials and ion enhanced deposition.

ANDERSON LABORATORIES, INC. *(Greendale, Wisconsin)*
Booth #1737 -- features materials testing to AMS, ASME, ASTM, AWS, GM & Military Standards. Chemical analysis utilizing spectrographic, as well as traditional wet methods. Mechanical testing including T Y & E, Charpy "U & V" notch to -321°F. Failure Analysis employing optical and scanning electron microscopy (SEM). Heat treat evaluation, plating composition and thickness. Corrosion (salt spray & humidity) testing. We are a General Motors and Pratt & Whitney approved laboratory.

ANTER LABORATORIES INC. *(Pittsburgh, Pennsylvania)*
Booth #1220 -- features dilatometers, thermal conductivity units.

A S M / M A T E R I A L S INFORMATION *(Materials Park, Ohio)*
Booth #1619 -- description not available at time of printing.

ASTRO MET, INC. *(Cincinnati, Ohio)*
Booth #1626 -- features custom ceramic wear components; foam and porous ceramics; and metal structures, setter plates, kiln furniture.

AVS INDUSTRIES *(Ayer, Massachusetts)*
Booth #1632 -- description not available at time of printing.

BAIKOWSKI INTERNATIONAL *(Charlotte, North Carolina)*
Booth #1223 -- description not available at time of printing.

BATTELLE *(Columbus, Ohio)*
Booth #1526 -- features research, development, and engineering services providing product design and manufacturing engineers with design, manufacturing, and materials technology to create leading edge products at competitive cost. Battelle's services permit existing operations to be more efficient, economical, and environmentally compatible. Battelle's innovative technologies include electronic ceramics; photonic materials: super-insulating aerogels; ceramic, metal, and polymer matrix composites; waste minimization; battery development; service life improvement methodologies; life cycle and environmental impact analysis; and corrosion sensors and corrosion research.

BOWSER-MORNER, INC. *(Dayton, Ohio)*
Booth #1509 -- features Bowser-Morner, Inc., who will be discussing their Research, Development, and Product Testing Capabilities for High Alloy Materials, Ceramics, and Composites.

Bowser-Morner will featute these capabilities for the Automotive, Aerospace, and Nuclear Industries. Of special interst will be Bowser-Morner's Corrosion Control plan for users of High Alloy Materials such as 304L, 316L, and C-276. This program can help assure that companies are using heats of materials with consistent corrosion properties.

BUEHLER LTD. *(Lake Bluff, Illinois)*
Booth #1228 -- features their complete line of sample preparation equipment, microscopes, hardness testers, an image analysis system, laboratory furniture, and related consumable supplies for the microstructural analyst. Included will be the ISOMET™ 2000 Precision Saw, ABRASIMATIC® 2 Automatic Abrasive Cutter, SUPERMET® 2 Grinder, SIMPLIMET® 3 Automatic Electro-Hydraulic Mounting Press, ECOMET® 4 Variable Speed Grinder/polisher, AUTOMET® 3 Microprocessor Controlled Power Head, and a select line of TECH-MET® Laboratory Furniture.

The highlight of the exhibit will be the new ALBRECHT Fully Automatic Sample Preparation System. Preparing samples in a fully automatic sequence from planar grinding to final polishing, this system can produce more than 300 specimens in eight hours. This breakthrough in sample preparation technology combines state-of-the-art robotics, microprocessors, user definable software logic and touch-screen controls with the revolutionary BUEHLER DIALOG® sample preparation procedures.

BUREAU OF MINES/U.S. DEPT. OF INTERIOR *(Washington, DC)*
Booth #1511 -- description not available at time of printing.

CARL ZEISS, INC. *(Thornwood, New York)*
Booth #1314 -- features a line of microscopes, the inverted AXIOMAT™ and AXIOVERT™ metallographs and the upright AXIOPLAN™ microscope. All feature new ICS optics.

The metallograph, stereo microscope and the VIDAS™ Image Analysis System are incorporated into a convenient work station "M.A.R.S.". State of the art video delivers hardcopies in color and allows for viewing by multiple users.

C.C. TECHNOLOGIES *(Columbus, Ohio)*
Booth #1431 -- features C.C. Technologies' engineering and research capabilities. C.C. Technologies is an engineering and research firm specializing in corrosion, corrosion control, evaluation of materials properties, materials selection, and design and development of instrumentation and engineering software.

C.C. Technologies has the capabilities to perform most corrosion and materials properties related testing. We are staffed with highly trained Ph.D. scientists and professional engineers who are nationally and internationally known research and engineering leaders in the fields of corrosion, fracture mechanics, and corrosion control. With this expertise, C.C. Technologies maintains a knowledge of the state-of-the-art techniques in corrosion and materials science, which permits the highest quality research, testing, engineering, design, failure analysis, and remaining life prediction to be performed.

CERACON, INC. *(Sacramento, California)*
Booth #1427 -- features the Ceracon Process™. The Ceracon Process™ is a quasi-isostatic, hot consolidation technique which utilizes a proprietary granular material as a pressure transmitting medium (PTM). For fabrication of parts, a cold iso-pressed or mechanically pressed preform is preheated and immersed in the hot PTM. Forming fully dense, near net shape parts in a matter of seconds, the Ceracon Technology provides industry with a cost effective solution to producing structurally sound parts in MMC, intermetallics, ferrous and non-ferrous alloys, refractory metals, engineered plastics and more. Preservation of rapidly solidified microstructures, ultra fine grain and carbide sizes, enhanced mechanical properties, and prevention of interfacial reactions are just a few of the technology's benefits.

CERAMIC INDUSTRY *(Solon, Ohio)*
Booth #1611 -- features copies of the magazine and subscription information.

CHARLES C. KAWIN CO. *(Broadview, Illinois)*
Booth #1417 -- features a metallurgical testing lab.

CHARLES EVANS & ASSOCIATES *(Redwood City, California)*
Booth #1527 -- features Charles Evans & Associates, who has recently enhanced its analytical capabilities by adding a new JEOL 200keV TEM, a JEOL Field Emission SEM, and a VG Gloquad to its already large suite of analytical instrumentation. Charles Evans & Associates is a complete analytical laboratory specializing in trace level and surface analysis.

CODONICS, INC. *(Middleburg Heights, Ohio)*
Booth #1201 -- description not available at time of printing.

COPPER DEVELOPMENT ASSN. *(Greenwich, Connecticut)*
Booth #1612 -- features copper data center. Copper Select.

CRYSTALITE CORP. *(Marina Del Rey, California)*
Booth #1511 -- features MASTERSYSTEM Metallographic Sample Preparation System Product line featuring the MASTERSYSTEM-600 Variable Speed Grinder/Polisher, the MASTERSYSTEM-800 Variable Speed Grinder/Polisher, and the MASTERSYSTEM-1000 Vibratory Polisher. Also featured are diamond and CBN grinding and polishing products and Metallographic sample preparation consumables.

CWC TEXTRON *(Muskegon, Michigan)*
Booth #2103 -- features steel castings.

DAVID SARNOFF RESEARCH CENTER *(Princeton, New Jersey)*
Booth #1231 -- features the David Sarnoff Research Center which has been a subsidiary of SRI International since 1987, and was formerly the corporate research laboratory of the RCA Corporation. With almost 50 years of experience, we provide an extensive array of research, development, and engineering services and a track record of success for advanced materials leading to advanced products. Technology areas highlighted in our exhibit include: Semiconductor Technology, Optoelectronic Materials, Electronic Packaging, Luminescent and Display Materials, Failure Analysis, Thin Film Technology, Organic Electronic Materials, Surface and Interface Science, Ceramic and

Metal Matrix Composites, Sol-Gel Technology, Plasma Processing, Powder Technology and Processing.

Technical Representatives will be available to discuss how the Sarnoff Center can help your organization improve existing products or create new products through advanced materials technology.

DIALOG INFORMATION SERVICES, INC. *(Palo Alto, California)*
Booth #1617 -- features providers of computer dial-up access to the largest collection of information available to the public. Subject coverage includes reference to all significant technical publications -- conference papers, technical journal articles, patents -- as well as product press releases. Company directories produced by Dun & Bradstreet, Standard & Poors, and others are also available. Dialog also offers instant access to leading newspaper and industry-specific newsletter articles. Data produced by the Materials Information service of ASM - Metadex, Engineered Materials, and more -- are available on DIALOG.

DUFFERS SCIENTIFIC, INC. *(Poestenkill, New York)*
Booth #2111 -- features state-of-the-art metallurgical process simulation -- including equipment for simulation of hot deformation, multi-stand rolling, continuous casting, welding, and continuous strip annealing. Applications engineers will be available to discuss how laboratory simulations can produce substantial savings in the research lab and on the production floor.

DU PONT CO. *(Wilmington, Delaware)*
Booth #1229 -- description not available at time of printing.

EDISON WELDING INSTITUTE *(Columbus, Ohio)*
Booth #2101 -- features the resource dedicated to improving U.S. manufacturing through materials joining technology. EWI's goal is to enhance the bottom-line performance and competitiveness of its over 200 member companies through improved quality, increased productivity, reduced cost, and extended product life.
Representing a broad range of joining needs, EWI engineers apply an in-depth knowledge of materials and their performance as they are affected by each specific joining process. For instance, EWI has developed a new multi-mode varistraint testing machine to better characterize the weldability of metals and their alloys. A model of this machine will be on display at the booth.

Other materials/joining related areas featured will include ferrous metals, advanced alloys and composites, ceramics and plastics.

E. A. FISCHIONE INSTRUMENTS, INC. *(Export, Pennsylvania)*
Booth #1329 -- features a series of TEM related products. Specimen preparation instruments include the Twin-Jet Electropolisher, the FIM/FEM Micro Polisher, the Digital Dimpling Grinder, and the Model 2000 Specimen Prep System, a state-of-the-art microprocessor based dimpling grinder. Also displayed will be SEM and TEM Specimen Holders for custom applications.

ELECTROSCAN CORPORATION *(Wilmington, Massachusetts)*
Booth #1434 -- features the Environmental Scanning Electron Microscope (ESEM). The ESEM opens the door to an unexplored world of microscopic phenomena unreachable with the high vacuum SEM. An historic breakthrough in electron beam instrumentation, the ESEM brings unprecendented power to bear on any micro-analytical problem. Insulators such as plastics, paper, ceramics, or glass are easily imaged without the need of applying a layer of artificial coatings. Observe and record dynamic processes, such as hydration/dehydration, absorption, melting, corrosion and crystallization. The ESEM's unique electron optics and revolutionary secondary electron detector make short work of observing even the most difficult specimens under "impossible" conditions.

ELMDAS *(Pennsylvania Furnace, Pennsylvania)*
Booth #TT12 -- description not available at time of printing.

E S MICROWARE *(Hamilton, Ohio)*
Booth #1608 -- features TAPP, a personal computer database of structural, thermochemical, and physical property data for over 10,000 solid, liquid and gaseous compounds. Properties include crystal structure, density, specific heat, enthalpy and free energy of formation, elastic moduli, thermal expansion, viscosity, and thermal conductivity. Properties are displayed in a spreadsheet format at temperatures input by the user. The program also includes phase diagrams for over 1000 binary metallic and ceramic systems. Navigation with icons and menus provides simple and rapid access to the data. TAPP runs on both Macintosh and Windows platforms.

FREUND PUBLISHING HOUSE LTD. *(Tel Aviv, Israel)*
Booth #TT7 -- features a publisher of more than 10 journals in the materials sciences and technology and in chemistry. We also publish books in the same fields. We offer co-publishing, co-production and

cooperative distribution services for new books and journals as well as translation and printing services.

GELLER MICROANALYTICAL LABORATORY *(Peabody, Massachusetts)*
Booth #1735 -- features analytical services, metallographic products and x-ray standards to the scientific community.

Analytical services include SEM, x-ray analysis (with both energy and multiple wavelength dispersive spectrometers), quantitative metallography, conventional metallography, and surface analysis using Auger electron spectroscopy.

Products include the patented "Counter-Rota-Cutter"; attachment for low speed metallographic saws (Buehler, LECO, and Struers) which increases cutting speed, improves surface finish, extends cutting depth 2X, and allows for thin sectioning of difficult to cut materials. Also offered are reference materials for Auger, XPS, X-ray and microprobe techniques, and the VACU-STORR high vacuum dessicators with holding times of 5 years.

GRIFF MACHINE PRODUCTS CO., INC. *(Pittsburgh, Pennsylvania)*
Booth #TT4 -- features grips, holders, bolt testing fixtures and accessories to fit all makes and models of testers manufactured by Tinius Olsen, Satec, MTS, Instron, Riehle, United and more.

That's all we've ever made, which gives you two significant advantages:

1. Our products are as good or better as any you'll find.
2. Our prices beat the OEM's, usually by at least 10%.

Griff also reconditions worn grips and custom makes others for hard to handle applications.

Griff stocks what we sell and offers the fastest turnaround available on out of stock items.

HAYNES INTERNATIONAL, INC. *(Kokomo, Indiana)*
Booth #1435 -- features a technology-oriented company devoted primarily to the development and manufacture of high-performance nickel-, cobalt- and iron-base alloys for severe corrosion and high-temperature service. The Company also produces titanium-base alloys used as seamless tubing in aircraft/aerospace applications.

Major facilities are in Kokomo, Indiana, where there are advanced melting, remelting and hot- and cold-rolling facilities. A facility for producing both seamless and welded tubular products is located in Arcadia, Louisiana. A complete facility for processing billet, bar, shapes, rod and wire is located in Openshaw, England.

HETHERINGTON, INC. *(Ventura, California)*
Booth #2105 -- features hydrogen and high vacuum furnaces for precision brazing, metal injection molding, ceramic injection molding, sintering, metallizing ceramics. Hot presses, bar sintering systems and powder debinding apparatus. Furnace accessories: work racks, work handlers, work loaders. See ad on page this page.

HOLOMETRIX, INC. *(Bedford, Massachusetts)*
Booth #1000 -- features thermal conductivity/diffusivity instruments.

IMPLANT SCIENCES CORPORATION *(Danvers, Massachusetts)*
Booth #1433 -- features a wide range of ion implantation products and services. In addition to direct ion implantation, the company offers ion beam sputter coating and ion beam mixing services to the aerospace, medical/dental, metalworking and semiconductor industries.

Also offered is a computer-based pin-on-disk system which simulates and measures sliding wear and friction. The ISC-200PC tests virtually any combination of metal, plastic, composite, glass or ceramic substrates. The unit consists of a gimbaled arm with pin attached, a fixture which accommodates disks up to 3" in diameter, an electronic force gauge and a computer chart recorder.

Wear testing services are also available in a controlled laboratory environment.

INCO ALLOYS INTERNATIONAL, INC. *(Huntington, West Virginia)*
Booth #1534 -- features a wide variety of high-performance nickel alloys including the MONEL, INCONEL, and INCOLOY series. Special emphasis will be given to more recent alloys developments such as INCOLOY alloy 925, INCOLOY alloy 800HT, INCONEL alloy 625LCF, INCONEL alloy 725, INCO alloy 25-6MO, and INCO alloy MS 250.

Shown in the booth will be samples of such innovative products as internally finned tubing, with internal fins that can increase the I.D. surface area by more than 10% without increasing the outside diameter. Materials for wallpapering and cladding lesser materials for corrosion resistance in pollution control equipment will be present.

Mechanically alloyed aluminum-lithium aircraft forgings and other mechanically alloyed products will also be featured.

INFORMATION HANDLING SERVICES *(Englewood, Colorado)*
Booth #1620 -- features CD-ROM Information Services from IHS. You can access full-text industry standards, military specifications and vendor catalogs right at your own personal computer. Full-text standards are available from many organizations, including ASTM, ASME and UL. All of IHS's Information Services are fully indexed so that you can locate the exact information you need, whether you know the document number, title or subject matter. IHS Information Services are updated regularly so you are always accessing the most current information available.

INFORMATION ON DEMAND, INC. *(McLean, Virginia)*
Booth #1615 -- features Information On Demand, Inc. (IOD), who locates and retrieves full-text copies of any publicly available document. IOD excels in the retrieval and delivery of standards and specifications, NTIS reports, U.S. and non-U.S. patents, conference proceedings, and journal articles. IOD also has special arrangements in place to provide document delivery for SCAN C2C, the only company in the United States to provide, in English, competitive information from Japan's leading scientific journals. To place an order, call and ask for Customer Service.

INSIGHT SCIENTIFIC INC. *(Simi Valley, California)*
Booth #TT9 -- features transparent brazing furnaces with advantages in process development and small parts production. Outer tube of furnace is transparent fused quartz with an advanced thin film coating that reflects heat back into the furnace core while simultaneously allowing an unsurpassed view of processes occuring within. The operator can visually monitor the process and make adjustments while it is taking place! Direct monitoring improves efficiency and increases understanding.

Also featured are *Cool Windows* for the furnace OEM and the furnace user. They reflect heat while transmitting visible light, allowing a clear view of the furnace core. This eliminates hot window hazards, decreases O-ring temperatures, reduces cooling requirements, and allows larger windows to be designed into the furnace without creating coldspots in the hot zone.

Insight Scientific also manufactures furnaces for crystal growth, optical fiber drawing, and thermophysical property measurement.

INSTRON CORPORATION *(Canton, Massachusetts)*
Booth #1334 -- features a Model 4502 test instrument with the new HRD (High Resolution Digital) Extensometer and the new 2 kip air grips performing R & N testing with the Series IX KYN Program. Also exhibiting a Model 8501 with a multi-channel data acquisition board and modular grips showing low cycle fatigue. The new high temperature Howmet extensometer (temps. to 1200°C) for TMF (thermal mechanical testing) will also be shown. Materials testing software will also be shown, highlighting the new FLAPS PLUS (Windows-based) program. This program for advanced fatigue testing includes a test previewing function, real-time graphics, calculation library and post-test processing spreadsheet capability.

INTERLAKEN TECHNOLOGY *(Eden Prairie, Minnesota)*
Booth #2110 -- features computer controlled servohydraulic materials testing instruments. PC based software provides complete control for the full range from advanced dynamic tests to tensile tests. Full range of accessories include grips, fixtures, extensometers, data acquisition systems, environmental chambers and furnaces.

IQS, INC. *(Cleveland, Ohio)*
Booth #1625 -- features an innovative organization specializing in quality assurance consulting, training and software. IQS has extensive experience in assisting companies in the steel and heat treat industries meet automotive and military requirements.

ISM TECHNOLOGIES, INC. *(San Diego, California)*
Booth #1529 -- features Advanced Industrial Surface Modification technology, including the MEVVA series of Metal Ion Implantation Systems. These are the only systems suitable for production level processing. Industrial Surface Modification with MEVVA Metal Ion Implantation Systems is used around the world to increase wear resistance, reduce friction, inhibit corrosion, and harden. It can be used on metals, ceramics, plastics and other materials. As an example, the process has bene shown to increase tool insert life by as much as a factor of five. ISM provides both MEVVA Metal Ion Implantation equipment and Industrial Surface Modification Services.

ISO SPECTRUM *(Columbus, Ohio)*
Booth #1624 -- description not available at time of printing.

J.W. LEMMENS, INC. *(St. Louis, Missouri)*
Booth #1414 -- features non-destructive testing instruments to measure elastic materials properties and damping. Based on the Impulse Excitation Technique (IET), the fundamental resonant frequencies of an object vibrating in a flexural, torsional or longitudinal mode are determined and displayed in digital form. From these frequencies, Young's Modulus, Shear Modulus and Poisson's Ratio can be calculated.

From the decay curve, the damping factor is calculated and the logarithmic decrement is shown in digital form.

For visco elastic materials, a different technique - Dynaliser - is used to obtain Young's Modulus and damping values. See ad on this page.

KAISER ROLLMET *(Irvine, California)*
Booth #1330 -- features Precision hollow Shapes by Cold Roll Extrusion.

Kaiser Rollmet has manufactured precision seamless cylindrical shapes for aerospace, defense and commercial applications utilizing the proprietary Roll Extrusion process, since 1967. This unique room temperature metal-forming technology is ideally suited for production of thin-walled, complex cylindrical shapes in diameters from 4 inches up to 72 inches. Virtually any deformable metal is suitable including aluminums, metal matrix composites, titaniums, inconels, precipitation hardening steels

through zirconiums. Practical tolerances on diameters and wall thicknesses are +/-.002" with lengths up to 24 feet attainable. Complete-to-print capabilities for rocket motor cases, launch tubes, pipe and liners for pressure vessels. Quality systems per MIL-I-45208A and ASME NCA-3800.

KELLERMANN MANUFACTURING CO. *(Wauconda, Illinois)*
Booth #TT5 -- features close tolerance, high quality aluminum, lead, zinc and ZA alloy permanent mold castings. Specialize in small to medium volume production. Castings from ounces to 50 lbs. Cast-in metal inserts, heat elements, and cal-rod capabilities. 12 proprietary molding machines up to 28 x 40 x 36 which combined with our in-house tool room eliminate design constraints of draft, coring and undercuts. Secondary operations include heat treating, filing, deburring, conventional machining and NC/CNC machining centers. A single source responsibility from die design through secondary operations, finishing and assembly. Process control system ensures repeatability of quality from run to run.

LAWRENCE LIVERMORE NATIONAL LABORATORY *(Livermore, California)*
Booth #1503 -- features The University of California, which operates the Lawrence Livermore National Laboratory (LLNL) for the U.S. Department of Energy (DOE). Representatives fron LLNL will be available to discuss technologies, patent licensing opportunities, and the possibility for collaborative arrangements with the Lab in several important areas, including: non-destructive evaluation technology, coatings, superplasticity of materials, composites technology, process modeling, and materials development and characterization.

LECO CORPORATION *(St. Joseph, Michigan)*
Booth #2116 -- features the LECO 2001 Image Analysis System with automatic stage for unattended operation. Additional instruments on display include the CM24A Automatic Cut-off Machine, PR35 Automatic Mounting Press, AP300 Automatic Polisher, LECO/OLYMPUS PMG-3 Inverted Metallograph, SZH Stereo Microscope, M400-G1 Microhardness Tester, and V100-C2 Macrohardness Tester. See us at The Heat Treat Show in the adjacent Booth #700.

LEICA INC. *(Deerfield, Illinois)*
Booth #1216 -- features a demonstration of exciting new products for materials science: Cambridge Instruments Q570 Image Analysis System, from Leica, and the Stereoscan 260, general purpose Scanning Electron Microscope with life time 3-D imaging and measurement capabilities. The Wild Leitz Aristomet Universal Materials Research Microscope, microscope accessories which include heating stages, microhardness tester and fully automated photomicrographic system, Stereo Microscopes and Macroscopes.

MAR-TEST INC. *(Cincinnati, Ohio)*
Booth #1320 -- features their capabilities in the mechanical testing of metals, composites, intermetallics, ceramics, and other advanced materials. Extensive facilities and specially designed test equipment account for unusually quick turnarounds of any size test programs in the areas of low cycle and high cycle fatigue, thermal-mechanical fatigue, cyclic crack growth, and numerous other test methods.

MARTIN MARIETTA ENERGY SYSTEMS *(Oak Ridge, Tennessee)*
Booth #1510 -- description not available at time of printing.

MATERIAL AID *(Windsor, Ontario, CANADA)*
Booth #1623 -- features an inexpensive computer-aided-learning package which teaches elementary concepts of materials science. It has been designed for freshmen engineering students, and developed as a supplement to lectures and textbooks. It has the advantage in that it can make use of dynamic illustrations such as dislocations moving or x-rays being diffracted. The person learning can use the modules over and over in privacy. The learning package will be valuable for executives, technicians and salespersons who want to improve their technical background in topics such as the heat treatment of steels. New modules, just completed on X-ray diffraction and diffusion, will be on display at the show. Sit down and try this novel teaching tool.

MATERIALS ANALYTICAL SERVICES, INC. *(Raleigh, North Carolina)*
Booth #1323 -- features a laboratory committed to quality materials analysis. Experienced analysts are employed to cover a wide variety of materials problems. In-house services include: SEM, TEM, FTIR, STM, XRD, and Optical Microscopy. Specialized services such as SIMS, XPS, and AES are also available.

METAL SAMPLES CO., INC. *(Munford, Alabama)*
Booth #1326 -- features test specimens for materials evaluation, which will be displayed in a variety of materials and dimensions. Other products/services include fasteners,

insulators, NDT reference kits, corrosion probes, a quality control department based on MIL-I-45208A, and a complete high tech machine shop utilizing CNC equipment with CAD/CAM capabilities. Machining of exotic and difficult alloys with laser and EDM technology is offered, as well asm, precision grinding, finishing and heat-treating. Metal Samples expanded operations this year by opening Alabama Research and Development Corp. for conducting medical, aerospace, and corrosion research projects. The company is the recipient of a U.S. Federal grant for one of its medical projects.

METALLON ENGINEERED MATERIAL CORPORATION *(Pawtucket, Rhode Island)*
Booth #TT11 -- features clad metals.

METALWORKING TECHNOLOGY, INC. *(Johnstown, Pennsylvania)*
Booth #1209 -- features MTI, who provides technical metalworking services to industry and government. Its goals are to develop high quality solutions enabling industry to produce net shape parts and their manufacturing processes correctly the first time, within an efficient, environmentally safe and cost-competitive manner. MTI operates the National Center for Excellence in Metalworking Technology (NCEMT) for the U.S. Navy Manufacturing Program. In support of this role, MTI has developed expertise in the following technical areas: Powder Metallurgy, Casting, Forging, Extrusion, etc. To support these efforts, MTI conducts advanced computer simulations with data collected from its state-of-the-art materials testing machines. MTI's support for small business, in addition, will expand considerably with its operation of the prototype CALS Shared Resource Center (CSRC). The CSRC should facilitate the improved economic competitiveness of small manufacturers.

METRON TECHNOLOGY *(Boulder, Colorado)*
Booth #TT8 -- features a new line of hand-held and bench-top industrial instruments for heat monitoring, thermal analysis and data acquisition. Digital data analysis and storage is now an opportunity for heat treating and materials development. The THERM products range from economical pyrometers to multi-channel data collection units which can utilize almost any type of thermocouple, RTD, thermistor or infrared sensor and have analog or RS-232 outputs. The instruments are designed to provide versatile solutions for operations and quality control within the materials/metals industries. METRON will provide free literature and have working demonstration instruments on hand.

MICROMERITICS *(Norcross, Georgia)*
Booth #2106 -- features particle size analyzers, B.E.T. Surface Analyzers which measure surface area and pore volume distribution, and Gas Pycnometers which measures the absolute density of powders, solids, and liquids.

MMA LABORATORIES *(Huntington Beach, California)*
Booth #1210 -- features MMA Laboratories, who currently tests for over 1500 companies throughout the U.S. for: Chemical Analysis, Physical Testing, Metallurgical Evaluation, NDT, Fatigue, Failure Analysis, Stress Rupture.

MPD NETWORK/STN INTERNATIONAL *(Columbus, Ohio)*
Booth #1614 -- features providers of access to over 100 of the world's most valuable scientific/technical databases. The Materials Property Data (MPD) Network, exclusive to STN, gives easy online access to worldwide sources of numeric data on materials property research and engineering. The MPD Network is the only service offering materials property data in one convenient place. Find answers to difficult materials property questions via the MPD search system, designed specifically for the materials science community.

MQS INSPECTION INC. *(Woodlawn, Ohio)*
Booth #1313 -- features the largest NDE/QA service organization in the United States. Headquartered in Chicago, MQS maintains 23 full service facilities nationwide providing leading edge inspection services to the power generation industry, aerospace, petro/chem, defense and automotive. As the MQS reputation and client list has grown, so have the number of advanced services now being offered. Personnel plus state of the art equipment and facilities, permits complete metallurgical and chemical analysis, welding, mechanical testing, machining, chemical etching and cleaning. Coupled with our ever expanding NDE capabilities, MQS has become a center of excellence that has helped thousands of companies become more productive.

MTS SYSTEMS CORP. *(Eden Prairie, Minnesota)*
Booth #1428 -- features dynamic test systems, software and accessories from its Material Test Division, a static test systems, software and accessories from its Sintech Division.

NANO INSTRUMENTS, INC. *(Knoxville, Tennessee)*
Booth #1001 -- features the NANO INDENTER™II. Ultra-low load indentation testing makes possible the determination of mechanical properties from surface layers less than 2000 Å thick. Hardness, elastic modulus and time-dependent

properties can be extracted from real-time load-displacement data which the NANO INDENTER™II obtains with resolutions of 75 nN and 0.04 nm, respectively. Spatial resolution of 0.4 μm makes possible determination of these properties from extremely small, well-defined regions within a sample. The NANO INDENTER™II is totally automated to run all experiments unattended in order to assure complete thermal and vibrational stability of the system, yielding very accurate, consistent data. Typical application areas to date have been sub-micron thin films, ion-implanted layers, multi-phase materials, interfaces in composites, and bulk materials in a wide variety of metals, ceramics and polymers.

NATIONAL FORGE COMPANY *(Andover, Massachusetts)*
Booth #1420 -- features the latest technologies and equipment for the high pressure industry including Hot Isostatic Presses, Cold Isostatic Presses (wet bag & dry bag), Quartz Crystal Growing Systems, Chemical Reactors, Deep Well and underwater simulators.

NATIONAL INSTITUTE OF STANDARDS & TECHNOLOGY (NIST) *(Gaithersburg, Maryland)*
Booth #1513 and 1515 -- features an agency of the U.S. Commerce Department's Technology Administration. Its mission is to strengthen U.S. industry's competitiveness, advance science, and improve public health, safety, and the environment.
NIST is a major center for materials research as well as an important source of reliable materials information. New research thrusts include intelligent processing of materials, high performance composites and ceramics, atomization of metal powders, HIP, and intermetallics. Major NIST programs in Standard Reference Data include phase equilibria, corrosion, tribology, properties of ceramics and com-posites, crystal structure, and surface science.

NAVAL RESEARCH LABORATORY *(Washington, D.C.)*
Booth #1506 -- features "Materials - Fabric for a Strong Navy", depicting twenty-two areas of current materials research.

NEWAGE INDUSTRIES, INC. *(Willow Grove, Pennsylvania)*
Booth #1633 -- features hardness testing instruments for testing according to the Rockwell, Brinell and Microhardness test methods. On display will be portable, bench and production units all with digital readout, built in statistical software and RS-232 output for printer or computer interface. Of special note will be our MT-90 Production Microhardness Testing System. Capable of doing automatic and fully programmable microhardness tests, the MT-90; can do effective case and decarburization studies in only 2 minutes. Also on display will be our Master Calibration/ Hardness Calibration Test Blocks, the only test blocks currently available in the U.S. that offer traceability to established independent international hardness value standards. The highlight of our display will be our new Brinell Optical Scanning System, the B.O.S.S. which is a fully automatic Brinell scope. Available as a PC based or portable hand held unit, the B.O.S.S. automatically reads Brinell impressions, and calculates the impression diameter and Brinell hardness value in under 2 seconds. For over forty years NewAge Industries has been a leader in the field of hardness testing and a stop by our booth will clearly demonstrate why.

NEW MEXICO ADVANCED MATERIALS AND MANUFACTURING TECHNOLOGY CONSORTIUM *(Los Alamos, New Mexico)*
Booth #1221 -- features research and development material and material processing.

NIKON INC., INSTRUMENT GROUP *(Melville, New York)*
Booth #1408 -- features Nikon Model QM-2 High Temperature Microhardness Tester, Nikon Model SMZ-U Stereo Research Microscope, Nikon Microphot-FXL Universal Research Microscope, Nikon Epiphot Inverted Metallograph.

NORAN INSTRUMENTS, INC. *(Middleton, Wisconsin)*
Booth #1312 -- features the Voyager, the latest in x-ray microanalysis technology providing image and chemical data from samples in a scanning electron microscope.

OLYMPUS CORPORATION-INDUSTRIAL FIBEROPTICS DIV. *(Lake Success, New York)*
Booth #1627 -- features Flexible Fiberoptic Borescopes (Fiberscopes) with interchangeable tips and four-way tip angulation, Rigid Borescopes, Miniborescopes, Light Sources plus full Video and Photographic accessories are available for internal remote visual inspection. Accurate comparisons can be made with photographic records of prior inspections to determine whether there has been crack growth or other progressive changes. Monitoring machinery photographically is far better than comparative opinion about the conditions of components.

OPTRA, INC. *(Beverly, Massachusetts)*
Booth #1432 -- features the Laser Extensometer 3000, a non-contacting, optical extensometer that does not require markings, targets, or preparation of the sample surface. This extensometer provides 5 microinch resolution and works equally well on ceramic, composite, metallic, and plastic materials. The Laser Extensometerwill monitor specimens enclosed in a chamber and is suited for applications combining high temperatures (> 2500°C), rapid cyclic fatigue, vacuum, radiation, and corrosive vapors.

ORBIT SEARCH SERVICE *(McLean, Virginia)*
Booth #1610 -- features an international leader in online information services. We provide users with access to over 100 databases heavily concentrated in the areas of science and technology. We will be providing live online searches on our extensive files covering materials, plastics, rubbers, ceramics and metallurgy. Stop by our booth with your search topics and we'll show you how ORBIT Search Service can provide you with the critical information you require while at the same time saving you money and more importantly time! Or if you can't make it by our booth call us toll free for more information.

ORTECH INTERNATIONAL *(Mississauga, Ontario, CANADA)*
Booth #1520 -- features an independent technical consulting and contract R&D organization. Business and technical viewpoints can be applied simultaneously to client's needs in areas including process and product development, materials selection, formulation, evaluation and specification testing for industry and government.

ORTON CERAMIC *(Westerville, Ohio)*
Booth #1423 -- features thermal analysis testing instruments including dilatometers for measuring thermal expansion/shrinkage from -170 to 1600°C and a thermal diffusivity/conductivity analyzer for continuous measurement of thermal diffusivity/conductivity of materials.

Also features, Testing and Analysis Services - a wide range of materials testing to understand the behavior of ceramic materials.

Other products offered by Orton include pyrometric cones and bars for measuring heatwork during firing and programmable temperature control systems for use with electric kilns.

PAYNE ENGINEERING *(Scott Depot, West Virginia)*
Booth #808 (in Heat Treating Show) -- features Payne Engineering, who has been recognized since 1959 for technical leadership in design and manufacturing dedicated to Solid State Motor Controls and SCR Power Controls. They will display the industry's most complete range of these products. Motor controls include: SENTROL EM3 series reduced voltage "Soft Starters", the award nominated 11DZ/EZ Solid State Relays designed to replace mercury displacement switches, and heavy duty series 11R Reversing Starters. Also featured: SCR Power Controls, designed for manual or remote signal operation for complete control in process heating applications up to 1200 amps at 480 volts. Free Literature and Applications Publications.

PENTON PUBLISHING *(Cleveland, Ohio)*
Booth #1602 -- features complimentary copies of, and information on, PENTON PUBLISHING'S Metals Group Trade Magazines: 33 METAL PRODUCING, 33 NON-FERROUS EDITION, FORGING, FOUNDRY MANAGEMENT & TECHNOLOGY, CASTING DESIGN & APPLICATION.

PHILIPS ELECTRONIC INSTRUMENTS CO. *(Mahwah, New Jersey)*
Booth #1203 -- features scanning electron microscopes.

POCO GRAPHITE, INC. *(Decatur, Texas)*
Booth #1416 -- features polycrystalline synthetic graphite, bulk materials and finished parts.

POLISHING SPECIALTIES CO. *(Newport News, Virginia)*
Booth #TT3 -- features a manufacturer/distributor of polishing, cutting and inspection equipment. • Ultra Tec MFG: Polishing machines and cutoff saws for industry and research. • Clark Taylor: Miniature diamond/conventional band-saw. • Crystalite: Diamond laps, polishing films, compounds, and slurries. • PSA: Inspection microscope, specialized polishing services. A full polishing lab is exhibited.

PRINCETON GAMMA-TECH, INC. *(Princeton, New Jersey)*
Booth #1331 -- features the IMAGIST™, a SUN™ workstation based system featuring advanced image processing and analysis capabilities for optical microscopy and video based analysis, and the IMIX™ system, with comprehensive EDS X-ray analysis and digital imaging capabilities for SEM, TEM and STEM. The Omega SLS™ a two atmosphere light element detector will also be on display.

PROCESS PRODUCTS CORPORATION *(N. Andover, Massachusetts)*
Booth #TT1 -- features state of the art rapid thermal processing systems modular constructed to integrate reduced pressure and mass flow Modular integration of PECVD-RTP-RIE-Magnatron Sputtering-Ion Beam Cleaning-Deposition-ECR Technology-RTCVD.

QUESTAR CORP. *(New Hope, Pennsylvania)*
Booth #1429 -- description not available at time of printing.

RICERCA, INC. *(Painesville, Ohio)*
Booth #1322 -- features a variety of analytical services provided by Ricerca for the materials industry. All major analytical techniques are included, as well as SEM, TEM and optical microscopy; elemental analyses by ICP, AAS, and HGA; XRD and XRF; physical testing such as BET, particle sizing,a nd image analysis. One-on-one personal consultations ensure that results and interpretations are communicated in a meaningful and confidential manner.

SAE *(Warrendale, Pennsylvania)*
Booth #1613 -- features hands-on product demonstrations of materials-related software packages (AMSearch® & UNSearch®), on-line and CD-ROM databases, and display of related publications. AMSearch is an electronic index allowing efficient access to document listings for over 2,500 Aerospace Material Specifications (AMS). UNSearch - Version 2.0 is time-saving software for electronically searching data on over 4,000 metal alloys by chemical composition (exact or range), common trade name (alloy), UNS designation, society designation, federal specification, military specification, or internal (company-specific) information. SAE is the publisher of thousands of technical papers, many specialized books, hundreds of standards, numerous reference volumes, software, and on-line databases.

SATEC SYSTEMS, INC. *(Grove City, Pennsylvania)*
Booth #1315 -- features a wide variety of mechanical equipment available from SATEC for an efficient approach to materials testing in today's market.

A fatigue rated Servo-Hydraulic load frame coupled with the MATS II PC-based automated control system offers the utmost in ease of operation, accurate and reliable data, and repeatable test execution.

SATEC's Table Top Model T5000 Electro-Mechanical Universal Test System: This system integrates load frame, control console and drive unit into one compact package offering a space efficient and economical test machine to perform testing applications, such as tension, compression, flexural, bend and shear.

LinkPac Acquisition and Control System for Creep and Stress-Rupture Testing: This system acquires thermocouple and strain data of many types and ranges for automating Creep and Stress-Rupture testing labs. LinkPac offers disk storage, report generation, alarm management, multitasking software and real-time graphical monitoring of test conditions.

SCHENCK PEGASUS CORP. *(Troy, Michigan)*
Booth #1409 -- features a Hydropuls® PSA material test system and S56 Digital Controller. The latest version of FMR, a general purpose material testing application with icon driven software will be demonstrated.

SHERRITT GORDON LIMITED *(Fort Saskatchewan, Alberta, CANADA)*
Booth #1413 -- features manufacturers of a wide range of highly specialized metal powders. A unique precipitation process enables Sherritt to supply metal powders with controlled particle size and surface morphology. These products are used in the aerogas turbine industry as abradable seal materials, in the electronics industry as conductive fillers and for industrial wear material applications.

Most of the specialty material products manufactured by Sherritt were developed in Sherritt's Research Centre. Following from this tradition, Sherritt formed Westaim Technologies Inc. in 1990. Westaim is the largest single advanced materials initiative ever undertaken in western Canada, dedicated to the research, development and commercialization of new products and processes. It is a cooperative research venture managed and led by Sherritt Gordon Limited, in cooperation with the Canadian federal government and the province of Alberta.

SHERRY LABORATORIES *(Muncie, Indiana)*
Booth #2108 -- features Metallurgical Testing: Chemistry analysis, failure analysis, metallography, weld qualification, tensile, creep/stree rupture, hardness, microhardness, hardenability, case depth, embrittlement, salt fog, SEM-EDS, metallographic examination.

Environmental Testing: Organic & inorganic, water analysis, wastewater, groundwaste, solid and hazardous waste, GC/MS, ICP, AA, sampling, discharge monitoring, asbestos, TCLP, foundry waste characterization, waste oil characterization.

SHIVA TECHNOLOGY *(Clay, New York)*
Booth #1522 -- description not available at time of printing.

SOUTH BAY TECHNOLOGY INC. *(San Clemente, California)*
Booth #1310 -- features sample preparation equipment for the following applications: 1) Lapping & Polishing; 2) Crystal Orientation; 3) TEM Sample Preparation; 4) Damage Free Sample Preparation; 5) Cutting & Sectioning (Wire Saws & Low Speed Diamond Wheel Saws).

NEW PRODUCTS on display include: • Ion Mill for TEM samples • UltraSonic Cutter • Lapping/Polishing Machine • XTEM Clamp.

Applications engineers will be available to address specific sample preparation requirements.

SPANG SPECIALTY METALS *(Butler, Pennsylvania)*
Booth #1328 -- features large picture panels displayed on a back wall featuring our Metals mill capabilities in producing nickel-iron alloys for the EMI/RFI shielding industry, and a vanadium-cobalt alloy for the aerospace industry. We also make available our mill's equipment for service work on customer supplied material.

S.S.B. TECHNOLOGIES *(Martinsville, New Jersey)*
Booth #TT10 -- features table-top, portable, solid state RF Generator for heating processes in industry and research. A large frequency range from 50 kHz to 1000 kHz allows a variety of applications. A 1.5 kw unit is on display but units to 20 kw will be available.

STRUERS, INC. *(Westlake, Ohio)*
Booth #1535 -- features a complete line of metallographic sample preparation equipment and supplies. On display will be our totally automated grinding and polishing system, PREPAMATIC. The operator places the samples in the machine, selects a preparation program, and the preparation process begins. From this point on, absolutely no operator intervention is required to prepare high quality specimens. In addition, we will also display our automatic cut-off machine, EXOTOM; our bench-top, cut-off machine, DISCOTOM-2;

our precision cut-off machine, ACCUTOM-2; our new, automatic, compression mounting press, PREDOPRESS; and our new, bench-top grinding and polishing system, ROTOPOL/FEDEMAT. Please visit us in booth 1535 for a demonstration and to learn more about our preparation methods.

TECHNOLOGY FOR ENERGY CORP. *(Knoxville, Tennessee)*
Booth #1309 -- features residual stress analyzer, product and service.

TENSILE TESTING *(Cleveland, Ohio)*
Booth #1630 -- features our Metallurgical Laboratory Services. This year we are highlighting FRACTURE TOUGHNESS through our presentation at the attendee briefing sessions.

This is one of our many services including: HOT TENSILES to 2000°F, STRESS RUPTURE, CHEMICAL ANALYSIS (Spectrographic & Leco), TENSILE TESTING (to 300,000 lbs.), CHARPY IMPACT (to -320°F), WELD QUALIFICATION, HEAT TREAT CAPABILITY, JOMINY END-QUENCH HARDENABILITY, METALLURGICAL SERVICES, METALLOGRAPHY, MICROHARDNESS, FAILURE ANALYSIS, SAWING & MACHINING Test Specimens. We are accredited by A2LA in the mechanical & chemical field along with various others in the nuclear, automotive, and aircraft industry.

Our newest service is SALT SPRAY.

TEXTRON SPECIALTY MATERIALS *(Lowell, Massachusetts)*
Booth #1005 -- description not available at time of printing.

THE ELECTROFUEL MFG. CO. LTD. *(Toronto, Ontario, Canada)*
Booth #1327 -- features equipment: hot press, dilatometer, sintering furnace, (Advanced cermaics), TiB, silicon nitride, BN Fibres, BN Solids.

THERMO ELECTRON/TECOMET *(Wilmington, Massachusetts)*
Booth #1404 -- features • Precision Machining • Near Net Forging • E.D.M. • E.B. Weld • Stamping • Forming • Certified Welding • Specialized Fabrications • Chemical Vapor Composites • Metal Matrix Composites.

THETA INDUSTRIES INC. *(Port Washington, New York)*
Booth #1233 -- features COMPUTERIZED DILATOMETERS FOR THERMAL EXPANSION MEASUREMENT: 1200°C Dilatronic I, 1700°C Dilatronic V, Computer Systems, Sensors.

DILATOMETER FOR METALLURGISTS: Dilatronic III - Quench Dilatometer for phase transformation and deformation studies, and alpha measurement. Dilatronic X - Powder metallurgy dilatometer to 1600°C.

FLASH DIFFUSIVITY APPARATUS: Conductronic IV for thermal conductivity measurements with pulse laser and alignment laser, Data processing, From -150°C to 2100°C.

HIGH TEMPERATURE VISCOMETERS FOR RHEOLOGICAL STUDIES: Rheotronic I/II rotating viscometers, 1100°C and 1600°C, Rheotronic III parallel-plate, 1100°C, Rheotronic IV bending beam, 1100°C, Rheotronic VII rotating, 1800°C, Rheotronic XII high temperature multi-instrument system.

TITLE III PROGRAM OFFICE *(Dayton, Ohio)*
Booth #1006 -- features an exhibit that describes the purpose of the Title III Program, current projects, project lifecycle, project locations, Title III contractors, "the necessary combination", project screening criteria, Title III Program objectives, stages of contract performance, purchase commitment requirements, and unique program aspects.

UES, INC. *(Dayton, Ohio)*
Booth #1533 -- features 1) Precision High Quality Friction and Wear Coatings, 2) ProCAST™ - The Professional Casting Simulation System

UNION CARBIDE ADVANCED CERAMICS *(Lakewood, Ohio)*
Booth #1321 -- features machinable ceramic composites, high purity ceramic powders, chemically vapor deposited (CVD) shapes and coatings. Powders include: BN, TiB_2, B_4C, AlN, and pre-cordierite. CVD products include: Pyrolytic BN, Pyrolytic Graphite, Si_3N_4, SiC, and metal carbide coatings (NbC, TaC, ZrC) which protect graphite from ablation, erosion, and chemical attack. Also available is a line of boron nitride spray and paints. Lubricious, inert, and non-reactive, BN coatings are useful as release agents, lubricants, and protective coatings in a wide variety of processes.

UNITRON INC. *(Bohemia, New York)*
Booth #1421 -- features new Versamet-3 Metallograph with all new super plan infinity corrected objectives offering brightfield, darkfield, polarized light and Nomarski in the same compact optical system. Also, shown will be Unitron's new Imaging Systems designed to meet the specific needs of the user, its complete line of Metallurgical Microscopes, new Stereo Microscopes, Measuring

Microscopes, CCTV and microscope accessories and optical components for OEM applications.

VACUUM FURNACE SYSTEMS CORPORATION *(Souderton, Pennsylvania)*
Booth #1734 -- features a new horizontal Model HL36BH Vacuum Furnace. This furnace will show a different approach in the design of a round graphite hot zone and an external "combined can" blower/heat exchanger arrangement. The new design will improve cooling efficiencies and will be easier to maintain.

VDM TECHNOLOGIES CORP. *(Parsippany, New Jersey)*
Booth #1303 -- features corrosion and high temperature resistant nickel base alloys and special stainless steels. Several new alloys have been developed recently for the chemical, pulp & paper, petrochemical, oil & gas production, and marine industries:
Alloy 59 has the highest pitting resistance equivalent number of the Ni-Cr-Mo family of alloys.
Alloy 48 is an age hardenable alloy for sour gas service.
Alloy 31 with high chromium molybdenum and nitrogen additions has corrosion resistance of alloys with twice the nickel content.
Alloy 24 a high chromium, manganes, very high nitrogen containing super stainless steel possessing a unique combination of corrosion, erosion and wear resistance.

WHITE ENGINEERING *(Newtown, Pennsylvania)*
Booth #1217 -- description not available at time of printing.

WOLPERT/PROBAT *(Ludwigshafen/Rhein, Germany)*
Booth #TT4 -- features materials testing equipment, hardness, tensile, impact, compression.

HEAT TREATING EXHIBITORS
(as of 920091)

1 Enthone-OMI, Inc. (Udylite)
3 Abbott Furnace Company
5 Cincinnati Sub-Zero
9 Triton Software, Inc.
13 All Trend Corporation
15 Pyrotek, Inc.
17 Heat Treating Network
19 Capintec Instruments, Inc.
21 Teledyne Hastings-Raydist
100 Fluxtron Manufacturing, Inc.
103 Buehler Ltd.
104 New Welduction
105 Partlow/Molytek Corp.
108 Metallwerk Plansee GmbH
109 Eurotherm Corporation
112 Zircar Products, Inc.
113 Eltech Thermal Systems Corp.
114 Lucifer Furnaces, Inc.
115 Advaco
116 Tocco Division
117 Worcester Polytechnic Institute
119 Mikron Instrument Co., Inc.
120 Tocco, Inc.
121 The Metal Works Industrial Furnaces
123 Amox Gas Generators
125 Airco Gases
129 Rolled Alloys
131 Union Carbide Industrial Gases
133 Kinney Vacuum
134 Process Technology Inc.
135 Jackson Transformer Company
136 Drayton Probe Systems, Ltd. (Instruments & Technology, Inc.)
200 E. F. Houghton & Co.
202 Televac Division of The Fredericks Co.
204 International Technical Ceramics, Inc.
206 Kurt J. Lesker Co.
207 Heatbath Corp.
208 Vacuum Research Corp.
209 Pyronics, Inc.
211 Econco
213 B & B Inductor & Transformer
214 Honeywell
215 Wolfson Heat Treatment Centre
217 Inspec
218 Leybold Technologies Inc.
219 Siemens Components, Inc.
221 Equotip Associates
223 Gruenberg Oven Company
224 Kolene Corporation
225 Custom Electric Mfg. Co.
227 Waukee Engineering Company, Inc.
228 Surface Combustion, Inc.
231 Maryland Wire Belts Inc
232 G-M Enterprises
233 Coors Ceramics Company
300 SBS Corporation
301 Air Products and Chemicals, Inc.
304 Lindberg, A Unit of General Signal
305 L & L Special Furnace Co. Inc.
308 Rolock/Calalloy
309 Electric Furnace Co.
311 Sierra Victor Co., Inc.
314 Park Chemical Company
317 Inland Vacuum Industries Inc.
318 Industrial Testing Labs, Inc.
319 Kloeckner Ionon of America, Inc.
324 Miller Consolidated Industries
325 Total Trac Systems Inc.
327 Mager Scientific, Inc.
328 J. L. Becker Company
329 Polycarbon Inc./Sigri Corporation
333 Gas Research Institute
334 Protection Controls, Inc.
338 Dependable Foundry Equipment Co.
340 National Vacuum Precision
342 Transmares Corporation
400 Inductoheat, Inc.
401 Tenaxol Inc.
404 Inductoheat Pty. Ltd.
405 Capital Induction, Inc.
408 HWG Inductoheat
409 Halmar/Robicon
414 Lepel Corporation
415 Seco/Warwick
418 Barber-Colman
419 Lindberg Heat Treating Co.
424 Eclipse Inc.
425 Aichelin-Stahl, Inc.
428 Climax Specialty Metals
429 Centorr and Vacuum Industries
432 Hess-MAE, Inc.
433 Aber Ipsen Industries
436 Inex Incorporated
438 Vacuum Tube Industries, Inc.
439 Great Lakes Carbon-Specialty Graphite
440 Magnatech, Inc.
442 Aerco American Alloys
443 Albern-Martin Industrial Furnace Co.
500 Leeds & Northrup
501 Stanwood Corporation
505 Furnace Control Corp.
506 Flinn & Dreffein Eng. Co.
508 Pacific Industrial Furnace Co., Division of Detrex Corp.
509 The Kanthal Corp/Furnace Products Division
514 Upton Industries, Inc.
515 Manoir Electroalloys Corp.
518 Hunterdon Transformer Company
519 Industrial Heat Recovery Equip., Inc.
520 M.G.P. Inc.
524 Vac-Aero International Inc.
525 Ajax Electric Company
528 Fiber Materials Inc.
529 Atmosphere Furnace Company
532 Krautkramer Branson
533 Industrial Heating Magazine
537 Como Industrial Equipment, Inc.
538 Thermal-Basic, Inc.
539 Zedmark Div. Quigley Co.
540 Metal-Lab, Inc.
541 Ulvac Sinku Riko, Inc.
543 Metal Treating Institute
544 Chameleon Application Software
600 Holcroft
601 Hauck Manufacturing Company
604 Contour Hardening
605 Williams Co. Inc.
608 Accutherm, Inc.
609 Marathon Monitors Inc.
614 Stokes Vacuum Inc.
615 Park Precision Inc.
618 K. J. Law Engineers, Inc.
619 Ajax Magnethermic Corporation
624 Radyne Corporation
625 PSI Energy
628 MG Industries
629 MPI Furnace Company
630 Control Concepts, Inc.
632 JMS Southeast
633 Castalloy Corporation
638 Can-Eng Sales (1985) Ltd.
639 Pillar Industries
642 Neturen Co. Ltd.
643 Pillar Industries - Maryland Division
700 Leco Corporation
701 C. I. Hayes Inc.
702 Leybold Vacuum Products Inc.
703 Leybold Inficon Inc.
704 Beavermatic, Inc.
705 Procedyne Corp.
708 Wilson Instruments Inc.
709 AGA Gas
710 Cleveland Electric Lab.
714 Oakland Metering Loaders
715 Calcarb, Inc.
716 THT Division, Dowa Mining Co., Ltd.
717 Foerster Instruments, Inc.
718 Therm Alliance Co.
719 Ircon Div/Square D Co.
724 Walmil Corporation
725 Induction Tooling, Inc.
728 Consolidated Engineering Company
729 AACC/Zircoa
731 Radiant Heat Corporation
733 Sheler Corporation
734 Vortek Industries Ltd.
736 Gautschi North America, Inc.
740 Granville-Phillips Company
741 Heat Treating Magazine
742 Thermco Instrument Corporation
743 Alpha 1 Induction Service Center
800 Siemens Energy & Automation, Inc.
801 Anafaze Measurement & Control
802 Bone Frontier Company
803 Metal Treating, Inc.
804 Penna-Flame Industries, Inc.
806 Sentry Equipment Corp.
808 Payne Engineering
809 United Testing Systems, Inc.
810 Richardson Electronics Ltd.
812 Alnor Instrument Co.
814 Noble Industrial Furnace
815 Metro Scale Company, Inc.
818 Datapaq
819 Salem Corp.
820 Weaver Industries, Inc.
822 T-M Vacuum Products Inc.
825 The Furnace Belt Co. Ltd.
827 Luxtron Corp., Accufiber Div.
829 DNF Vacuum Equipment Service Co.
830 Rapid Technologies, Inc.
831 Manning U.S.A.
833 Fuel Conservation Services Inc.
834 Dayton Rogers Manufacturing Co.
835 CFI Industrial Furnace
900 Cooley Wire Products Mfg. Co.
901 Sandtex Inc.
902 Williamson Corp.
904 Liquid Air Corporation
905 MKS Instruments, Inc.
906 The Carborundum Company
907 Thermal Technology Inc.
909 Wall Colmonoy Corporation
910 Despatch Industries
911 OilPure Systems
912 Wirco Inc.
914 MVAK Technologies, Inc.
915 Graphite Die Mold Inc.
916 Elnik Systems, Div. of IPM, Inc.
917 Watlow
920 Onspec, Inc.
921 Evey Engineering Company, Inc.
922 A-Lab Corp.
923 FMJ

NOTE: additional Heat Treating exhibits can be viewed in the concurrent Materials Exposition -- PLAN TO VISIT THESE BOOTHS, TOO!

HEAT TREATING DIVISION SALES & MARKETING COMMITTEE

Mr. Eric Manos, Chairman
Buehler UK Ltd.
Coventry UK

Mr. Dave Rinz, Vice Chairman
Vacuum Furnace Systems Corp.
Souderton, PA 18964

Mr. Larry Bruder
Leica
Deerfield, IL 60015

Mr. Joseph Ciarlone
Kolene Corporation
Detroit, MI 48223

Mr. Mike Doerr
K.J. Law Engineers, Inc.
Novi, MI 48050

Mr. Robert P. Driscoll
Buehler Ltd.
Lake Bluff, IL 60044

Mr. Bill Girdwood
Surface Combustion Inc.
Maumee, OH 43537

Mr. Doug Glenn
Seco/Warwick Corporation
Meadville, PA 16335-3618

Mr. Dante A. Iacovoni
Lindberg/Unit of General Signal
Blue Island, IL 60406

Ms. Susan Ketterlinus
Honeywell, Inc.
Fort Washington, PA 19034

Mr. Paul Miller
Inductoheat
Madison Heights, MI 48071

Mr. David F. Simion
Robotron
Southfield, MI 48086

Mr. Ernest Walen
Heatbath Corporation
Indian Orchard, MA 01151

AACC/ZIRCOA *(Solon, Ohio)*
Booth #729 -- features AACC/ZIRCOA. Prepare now for 1992's tighter quality requirements...our Model 1992 Carbon Control System, with dual setpoint capabilities, offers you the following advantages: • improves product quality • improves process efficiency • provides air purge sensor technology • offers boost and diffuse capability • one-year sensor warranty • two-year system warranty.

...Improve your heat processing efficiency by networking your PCs into a powerful data acquisition and control system Take complete control over your heat processing variables - temperature, time, atmosphere and other functions. This automated system frees you to manage multiple heat-related process operations through multitasking - wherever there is a workstations

PRACTICAL ATMOSPHERE CONTROL SOLUTIONS.

ABAR IPSEN INDUSTRIES
(Feasterville, Pennsylvania)
Booth #433 -- features a part of the $1.6 billion TI group. They offer you the opportunity to benefit from the world's most dynamic thermal processing research and engineering talent in the industry. New product introductions include: Vacuum Deoiling, an environmentally safe alternative for parts cleaning and the Gas Fired Ion Nitrider, a unique gas fired vacuum furnace. Additional featured products include: Advanced Atmosphere Furnace Systems and our TurboTreater, MetalMaster, and Convection Vacuum Furnaces.

ABBOTT FURNACE COMPANY *(St. Marys, Pennsylvania)*
Booth #3 -- features Abbott, who offers a variety of custom designed continuous heat treat lines. Abbott incorporates creativity, quality and experience into it's manual, semi-automated, and fully-automated heat treat lines to meet customer needs. Abbott's heat treaters range in size from 6" cube inside working area (tool room) to continuous heat treating lines capable of 1000 lbs of product per hour. Ancillary equipment includes parts washers, and/or, draw furnace/ovens.

ACCUTHERM, INC.
(Pataskala, Ohio)
Booth #608 -- features two of the many types of heat treating furnaces manufactured by Accutherm. Units displayed show the results of constant quality advancements within the furnace manufacturing industry. Modern digital controls and multiple varieties of ceramics and metals used within the newly designed furnaces give wear resistance where needed and light weight efficiency where permissible.

This display shows that even small heat treating furnaces are stepping into the future.

Accompanying photos show many of the more sophisticated furnaces designed and manufactured by Accutherm.

ADVACO *(Westminster, Maryland)*
Booth #115 -- features complete rebuilding services for mechanical vacuum pumps, roots-type blowers, diffusion pumps, cryogenic pumps, and Helium leak detectors. Extensive refurbishment techniques will be introduced which allow for complete pump overhaul to original manufacturer's specifications without replacement of major parts. A one year warranty will be offered for all rebuilding services.

AERCO AMERICAN ALLOYS INC. *(Detroit, Michigan)*
Booth #442 -- description not available at time of printing.

AGA GAS *(Cleveland, Ohio)*
Booth #709 -- features Flexair family of atmosphere systems and technology for heat treating applications: hardening, carburizing, ferrous and non-ferrous annealing, brazing, sintering and nitrocarburizing. Highlighted will be the NITROFLEX™ system for gaseous ferritic nitrocarburizing. Also featured will be the NitroPRIME™ PSA and Membrane systems for generating nitrogen.

AICHELIN-STAHL, INC.
(Kingsville, Missouri)
Booth #425 -- features photo coverage of our broad spectrum product line of furnaces and companion material handling equipment. We will have an experienced team available at all times to discuss equipment and processes. Specially featured in our booth will be the AICHELIN-FOCOS program for furnace operation control and optimization.

Also featured will be our FLEXICLEAN washer system which is designed to replace solvent washers and degreasers, while remaining ecologically friendly.

AIRCO GASES *(Murray Hill, New Jersey)*
Booth #125 -- features industrial gases and advanced technologies for the heat treating/brazing and metalworking processes. We offer nitrogen, hydrogen, argon, helium and special gases and advanced cryogenic and non-cryogenic (PSA/membrane) on-site nitrogen generators; atmosphere technologies for reducing cooling rates, removing carbon deposition in annealing, bright annealing, heating for forging, controlled oxidation, hardening and carburization; consulting and trouble-shooting services. In addition, we are introducing the TEL-TANK which is a sophisticated telemetry system and the AIRCO HYDROGEN ATMOSPHERE systems (AHA), used for the advanced furnace designs.

AIR PRODUCTS AND CHEMICALS, INC. *(Allentown, Pennsylvania)*
Booth #301 -- features Air Product's introduction of a new line of PURIFIER™ heat treating atmospheres that will enable a large percentage of atmosphere users to improve the quality of their products without increasing the overall cost.

AJAX ELECTRIC COMPANY *(Huntingdon Valley, Pennsylvania)*
Booth #525 -- features application and service engineers, who will be on hand to discuss features of custom designed heat treat systems integrating atmosphere, fluidbed, and salt heating technologies with isothermal quenching. Advanced process control and data acquisition • Salt recovery • Water addition • Electrical control systems • Surface cleaning equipment for complete removal of paints, plastics, scale, ceramics, etc. with necessary salts and chemicals.

AJAX MAGNETHERMIC CORPORATION *(Warren, Ohio*
Booth #619 -- features induction heat treating equipment and will show a skid-mounted lift and rotate pick and place hardening system with computer control and Q.C.

A-LAB CORP. *(Dayton, Ohio)*
Booth #922 -- features a full service metallurgical testing laboratory providing technical evaluation in Nondestructive, Mechanical Testing, Chemical Analysis, Machining, Metallography, Failure Analysis, and SEM services.

A-Lab is a member of the American Council of Independent Laboratories and other professional affiliations.

ALHERN-MARTIN INDUSTRIAL FURNACE CO. *(Troy, Michigan)*
Booth #443 -- description not available at time of printing.

ALL TREND CORPORATION *(Ft. Lauderdale, Florida)*
Booth #13 -- features: • Vacuum furnace on display in limited operation; • "ToolTreateR" Model, 2400°F for High Speed Steel; • Featuring new "Hillfire" long-life Moly wire heating elements; • Low cost manual operation for processing small lots to specifications; • Provides immediate custom service for commercial heat treaters; • Does small jobs of High Speed Steel profitably; • Photographs and literature of full line of vacuum furnaces; • Standard sizes from 6" x 12" to 24" x 48", all rapid quenching.

ALNOR INSTRUMENT CO. *(Skokie, Illinois)*
Booth #812 -- features their Dewpointer and rugged line of portable Pyrometers. In addition, Alnor is offering a 10% discount coupon on calibration or repair of any Alnor instrument to anyone stopping and completing an industrial instrument survey.

ALPHA 1 INDUCTION SERVICE CENTER *(Columbus, Ohio)*
Booth #743 -- features a complete Induction Service Center specializing in the repair, reconditioning and design of Induction Coils, Transformers, Special Tooling, Quick Change buss, Flux Concentrators, Field Service Technicians, Control Systems, Power Supplies, and Turn Key Induction Systems. Sales engineers will be available to answer questions and to help solve any of your Induction Service Problems. Complete literature describing the full line of services as well as samples and photographs of equipment will be on display.

AMOX GAS GENERATORS *(Louisville, Kentucky)*
Booth #123 -- features a complete line of nitrogen generators that will produce nearly any flow, purity and pressure required for heat treating needs. The Amox process simply filters compressed air through a molecular sieve to provide up to 99.9% pure nitrogen with a dew point below -100 degrees F. Nitrogen cylinder filling stations are available, too. You can make your own nitrogen at a fraction of the cost of buying expensive high pressure cylinders or bulk liquid. See Amox at booth #123 for more information about making your own nitrogen from compressed air!

ANAFAZE MEASUREMENT & CONTROL *(Santa Cruz, California)*
Booth #801 -- features controls and SPC software for Temperature, Carbon Potential, Dew Point, Gas Flows, Belt Speeds and other heat treating processes.

The 1/4 DIN ANAFAZE 8LS-CP provides 8 fully independent dual-output PID loops with control and direct readout of % carbon potential, Dew Point, probe Millivolts, as well as process temperatures in degrees F or C. The ramp and soak feature allows fully automatic boost-diffuse carbonizing. To save time, you can setup the system parameters from 8 jobs stored in the control's protected memory.

Built in serial interface allows controllers to be the key element for computer supervised data acquisition and control system. ANAFAZE offers CARBONSOFT, an easy to use menu driven software package, that allows process setup, process overviews, batch plot trending with print outs, and data storage in Lotus compatible files for SPC functions.

ATMOSPHERE FURNACE COMPANY *(Wixom, Michigan)*
Booth #529 -- features a family of universal integral quench batch systems; mesh belt systems, pusher carburizers, roller hearth systems, cast belt conveyor systems, micro processor based control systems, all types of austempering systems.

BARBER-COLMAN *(Loves Park, Illinois)*
Booth #418 -- features process/temperature controllers offering options such as digital communications, auto-tuning and Insta-Set® recipe storage. New products include the MSQ 1/4 DIN single zone process/temperature controller with front panel access for up to 16 process recipes and upload/download capability with Insta-Set 16K memory card. Also new is a CIMAC™ Series multi-zone controller/programmer with the capability for control of up to eight process/temperature control zones. Included are sensors, carburization control and recorder products and information on power controllers, actuators and valves. Controls will be networked featuring the Barber-Colman CIMAC Supervisory system.

B & B INDUCTOR & TRANSFORMER *(Cleveland, Ohio)*
Booth #213 -- description not available at time of printing.

BEAVERMATIC, INC. *(Rockford, Illinois)*
Booth #704 -- features internal quench, temper, vacuum, car bottom, box, belt, and roller hearth furnaces. As well as washers, generators, freezer/chillers, and other specialized units. We also offer services such as furnace retro-fitting, conversions, and complete turnkey installations.

BONE FRONTIER COMPANY *(Brighton, Colorado)*
Booth #802 -- features induction heating systems - from very small size 2.5 Kw, to 1000 Kw. Frequencies to 25 KhZ. Complete turn key systems for HEAT TREAT. BRAZOS Power units for low power. A 10Kw unit is only 24" x 24" x 24".

BUEHLER LTD. *(Lake Bluff, Illinois)*
Booth #103 -- features a complete line of sample preparation equipment, microscopes, hardness testers, image analysis systems and related consumable supplies for the microstructural analyst.

Highlighting the exhibit will be the ECOMET® 3 Variable Speed Grinder/Polisher interfaced with the AUTOMET® 3 Microprocessor Controlled Power Head and METLAP™ 1 Programmable Fluid Dispensing System for automatic high volume sample preparation applications. This system, when combined with the BUEHLER DIALOG® methods of sample preparation, will provide superior preparation results, a dramatic reduction in preparation time, and a drastic savings in consumables when compared to conventional preparation methods.

CALCARB, INC. *(Rancocas, New Jersey)*
Booth #715 -- features quality assurance certificate B & 5750 PT2, ISO9002, manufactured in Scotland. Carbon bonded carbon fiber, for use in high temp vacuum sintering, aerospace, crystal growing, advanced composite, high temperature graphatizing, and heat treating applications. We will show a cylinder as well as samples of our material. Stop by and discuss your application.

CAN-ENG SALES (1985) LTD. *(Niagara Falls, Ontario, CANADA)*
Booth #638 -- features a complete range of heat processing equipment for the treatment of ferrous and non-ferrous metals. Whether you need a basic box furnace, and electrically-heated or gas-fired fluidized bed system, a

high efficiency walking beam, a high volume cast belt line or a turn key continuous mesh belt carburizing line complete with loader, quench, wash and draw furnace, we would like to talk with you.

CAPINTEC INSTRUMENTS, INC. *(Ramsey, New Jersey)*
Booth #19 -- features portable and on-line non-contact pyrometers to cover applications up to 4500°F.

Portables feature the HOTSHOT two-color ratio pyrometer which makes emissivity-independent measurements from 1100° to 4500°F and is immune from the effects of smoke and dirty sight glass windows.

Fixed units include ruggedized sensors and transmitters for OEM use as well as complete instrument systems for furnace applications. The RATIOSCOPE models offers two-color performance from 400° to 4500°F in a variety of configurations. Other models have extremely compact size with fiber optics for installation in tight locations.

CAPITAL INDUCTION, INC. *(Sterling Heights, Michigan)*
Bootn #405 -- description not available at time of printing.

CASTALLOY CORPORATION *(Waukesha, Wisconsin)*
Booth #633 -- features Castalloy's quality line of cast belts, trays, fixtures and other high alloy heat resistant castings, specifically designed for optimum performance in your heat-treating furnaces. This booth will also feature a complete pictorial display of Castalloy Corporation's modern facility, quality control procedures and various representative castings.

Sales personnel from all states, as well as our technical staff, will be available to answer your questions.

CENTORR AND VACUUM INDUSTRIES *(Feasterville, Pennsylvania)*
Booth #429 -- features a part of the $1.6 billion TI group. They offer you the opportunity to benefit from the world's most dynamic thermal processing research and engineering talent in the industry. New product introductions include: The M61 Furnace, a high temperature vacuum or controlled atmosphere research furnace. Additional featured products include: The System VII/Super VII, a multipurpose vacuum metallurgical furnace and our 2A Gettering Furnace, a high temperature gas purifier furnace system.

CFI INDUSTRIAL FURNACE *(Wilmington, North Carolina)*
Booth #835 -- description not available at time of printing.

CHAMELEON APPLICATION SOFTWARE *(El Toro, California)*
Booth #544 -- description not available at time of printing.

C. I. HAYES INC. *(Cranston, Rhode Island)*
Booth #701 -- features vacuum and atmosphere furnaces for heat treating, brazing, sintering, annealing, tempering and glass-to-metal sealing.

CINCINNATI SUB-ZERO *(Cincinnati, Ohio)*
Booth #5 -- features a display of state-of-the-art low temperature steel treating equipment. The booth will be manned by factory sales engineers who will provide technical information for other low temperature applications.

CLEVELAND ELECTRIC LAB. *(Twinsburg, Ohio)*
Booth #710 -- description not available at time of printing.

CLIMAX SPECIALTY METALS *(Cleveland, Ohio)*
Booth #428 -- features samples of molybdenum bar, rod, sheet and plate as well as tungsten sheet, plate and foil. A representative profile of extrusion samples to reflect large diameter tubes, solid shapes and coils from large difficult-to-extrude materials.

COMO INDUSTRIAL EQUIPMENT, INC. *(Kalida, Ohio)*
Booth #537 -- features Filters & Filtration Equipment For Quench Oil.

Now you can have clean oil all the time. Temperatures up to 425 deg. F. Como Patented Filter design produces maximum dirt holding capacity & efficient carbon removal. Filters & Filtration Equipment for all quench fluids. Recycling Equipment also available.

Distributor: Contamination Control Specialists, Inc., Kalida, Ohio.

CONSOLIDATED ENGINEERING COMPANY *(Kennesaw [Atlanta], Georgia)*
Booth #728 -- features a pictorial display with accompanying literature, which will provide an overview of CEC's complete line of both standard and custom engineered furnaces, systems and ovens. Featured equipment will be carbottom, roller hearth, drop bottom, box, pit and continuous belt furnaces, as well as a wide range of custom furnaces and ovens for the heat treating, aluminum, steel, ceramics and composites industries. See ad on inside front cover of Heat Treat section.

CONTOUR HARDENING *(Indianapolis, Indiana)*
Booth #604 -- description not available at time of printing.

CONTROL CONCEPTS, INC. *(Minneapolis, Minnesota)*
Booth #630 -- features a manufacaturer of SCR power controllers intended for industrial process heating applications. Zero-cross and phase-angle controllers with current ratings from 10 to 1000 amps for either single or three-phase applications are in stock for immediate shipment. Controllers are available for demanind applications; variable resistance loads like silicon carbide, graphite, molkybdenum disilicide loads, transformer coupled loads using Scott-T transformers, and induction heating applications.

Theory of operation and application of zero-cross and phase angle controllers will be discussed and demonstrated. A unique feature called "Sync-Guard" which reduces synchronous operation of zero-cross controllers will also be shown.

COOLEY WIRE PRODUCTS MFG. CO. *(Schiller Park, Illinois)*
Booth #900 -- features heat & corrosion resistant fabrications and wire cloth. Featured will be a pressure welded basket and liner, round baskets and their lifting posts for fluidized beds and an assortment of woven wire cloth.

COORS CERAMICS COMPANY *(Golden, Colorado)*
Booth #233 -- features Coors Ceramics Company, who offers Thermal Process Components or Molten Metals for applications such as casting tips, choke valves, launders, submersible pumps, mixing blades, emersion tubes and pump linings. Materials available include silicon carbide, aluminum titanate and silicon nitride.

CUSTOM ELECTRIC MFG. CO. *(Livonia, Michigan)*
Booth #225 -- description not available at time of printing.

DATAPAQ *(Wilmington, Massachusetts)*
Booth #818 -- features leaders in the field of temperature measurement and analysis. They will introduce the only temperature monitoring and analysis system available for long duration, high temperature, conveyorized furnaces and lehrs. Furnace Tracker provides complete temperature profiles of a variety of processes including heat treating, aluminium and vacuum brazing, use of quench, tempering lehrs, and many other unique, long duration, high temperature procedures.

DAYTON ROGERS MANUFACTURING CO. *(Minneapolis, Minnesota)*
Booth #834 -- features Dayton Rogers. Now you can automatically bend sheet metal parts, bars and rounds up to 24" long to within ±.002". Dayton Roger's new computer-driven "Smart Press" eliminates the guesswork of traditional straightening with jigs and fixtures.

By bending with a brain instead of brawn, overbending and breakage are virtually eliminated. Cycle time takes just seconds, after set up. Best of all, a "Smart Press" operates easily by an unskilled worker after minimal training.

DEPENDABLE FOUNDRY EQUIPMENT CO. *(Tualatin, Oregon)*
Booth #338 -- features photographs of heat processing equipment manufactured at their Tualatin, Oregon facility. Highlighted will be Fluid furnaces Carbottom furnaces, Roller Hearth furnaces, Drop Bottom furnaces and Conveyorized furnaces. Literature and information will be available discussing and describing the custom built equipment manufactured by Thermal Products Division. The booth will be manned by personnel experienced in customizing equipment to individual needs. Cost comparisons are available depicting the efficiencies of custom fitted equipment.

DESPATCH INDUSTRIES *(Minneapolis, Minnesota)*
Booth #910 -- features various ovens and furnaces ranging from small standard units to large custom installations. Particular focus is given to Aluminum Solution Heat Treat Systems including polymer quench systems.

DNF VACUUM EQUIPMENT SERVICE CO. *(Bohemia, New York)*
Booth #829 -- features field leak testing of all vacuum processing equipment and furnaces. Plus, repair and rebuilding of leak detectors and vacuum pumps.

On display will be a heavy duty leak test - vacuum pump cart, for use in heat treating environments.

DRAYTON PROBE SYSTEMS, LTD. (INSTRUMENTS & TECHNOLOGY, INC.) *(Naperville, Illinois)*
Booth #136 -- features demonstrations of laboratory and portable QUENCHALYZERs.

These systems characterize quenchants via cooling curve analysis. The laboratory system is in use world wide by quenchant suppliers and users of oil and aqueous polymer quenchants. The portable model extends the capability to the shop floor and in-tank testing. Comprehensive software is available for displaying cooling curves/cooling rate curves on the CRT. Key numeric values are generated for process control and limits can be set for automatic alarm when exceeded. Extensive data storage permits easy comparison of previous cooling curves.

ECLIPSE INC. *(Rockford, Illinois)*
Booth #424 -- features process heating equipment and systems.

ECONCO *(Woodland, California)*
Booth #211 -- description not available at time of printing.

E. F. HOUGHTON & CO. *(Valley Forge, Pennsylvania)*
Booth #200 -- features Aqua-Quench aqueous polymer, which cools like oil and leaves dry easily cleanable film. Aqua-Quench 3600 aqueous polymer is based on polyethyloxazoline. This series of products has cooling rates similar to those of quenching oils, but has lower drag out than conventional glycol quenchants and a residual film after processing that is completely dry. There's no stickiness on workpieces, machines, furnaces or shop floors.

Advantages are: • no petroleum oil smoke or fire hazard • parts clean easily • non-polluting to atmosphere or plant environment • cost is lower (Aqua-Quench 3600 series are concentrates) • less distortion than with other polymer quenches • can be used to quench high hardenability alloy steels • reduced insurance premiums, less fire protection equipment, and no quench oil fire downtime.

ELECTRIC FURNACE CO. *(Salem, Ohio)*
Booth #309 -- features information on the facilities, personnel, and products of Electric Furnace Co. We custom design, manufacture, and install batch and continuous fuel fired and electric furnaces and auxiliaries for annealing, brazing, carburizing, hardening, sintering and tempering of ferrous and non-ferrous castings, fasteners, forgings, stampings, strip and tubing in air or special atmospheres.

ELNIK SYSTEMS, DIV. OF IPM, INC. *(Fairfield, New Jersey)*
Booth #916 -- features:

• high temperature vacuum or controlled atmosphere furnaces with temperatures to 3000 degrees C and vacuum levels to 10 -8 Torr, for heat treating, sintering, brazing, ceramic to metal joining, annealing, degassing, stress relieving, aging, tempering, carburizing, hardening, ceramic metalizing, glass processing, etc.

• Oil free, ultra clean infrared heated vacuum ovens to 750 degrees C and 10 -8 Torr for delicate and superclean processing.

• Oil free vacuum pumps and pump systems.

• Temperature recorders for heat treating applications.

ELTECH THERMAL SYSTEMS CORP. *(Streetsboro, Ohio)*
Booth #113 -- features the complete line of industrial burners, flame monitoring devices, gas control valves and pressure regulators manufactured by Kromschroeder, AG of Osnabrueck, Germany. Eltech has a license to manufacture and sell all Kromschroeder burners and another license to sell only all other Kromschroeder combustion components and provide service in the U.S., Canada and Mexico.

ENTHONE-OMI, INC. (UDYLITE) *(New Haven, Connecticut)*
Booth #1 -- features a major supplier of specialty chemicals to the metal finishing industry. They will feature CUPRAL™, a non-cyanide copper plating process for heat treat stop-off. CUPRAL plates a pure copper deposit. Its dense, non-porous grain structure means thinner deposits can be used. Distribution and adhesion exceed cyanide systems. Process control is simple. There is no carbonate build-up, no carbonate treatment.

EQUOTIP ASSOCIATES *(Denver, Colorado)*
Booth #221 -- features the NEW-EQUOTIP portable hardness testers with a large LCD display on which all information is visible at a glance. The hardness value "L" is automatically converted and displayed to other hardness scale values such as HRC/HB/HS/HV. The conversion tables for commonly used materials previously supplied in tabular form are now integrated in the measuring device. As the electronics sense which type of impact device is connected, conversion always takes place according to the correct tables.

EUROTHERM CORPORATION *(Reston, Virginia)*
Booth #109 -- features a manufacturer of controls and control solutions for the heat treating industry. On display will be the 90 series of low cost instruments including the FM

approved 93 alarm unit. The 900 series features Eurotherm's new carbon potential controller and valve positioners. Also demonstrated will be Eurotherm's line of quality SCR products. New products displayed will include Eurotherm's PC3000-A complete control solution for the heat treating industry.

EVEY ENGINEERING COMPANY, INC. *(Vineland, New Jersey)*
Booth #921 -- features Evey Engineering Company, the one source for all of your vacuum needs. Our factory trained service personnel can rebuild your present vacuum system to meet original equipment specifications. We warehouse a large inventory of new and rebuilt vacuum equipment for direct replacement, system upgrade or new installations. Our complete stock of maintenance items, fluids, parts and accessories will help you to insure the optimum uptime on your vacuum equipment. Call Evey for all your vacuum needs.

FIBER MATERIALS INC. *(Biddeford, Maine)*
Booth #528 -- features a leading manufacturer of high temperature carbon and graphite insulation and structural materials for heat treating furnaces.

FMI produces carbon and graphite felts as well as lightweight and durable rigid carbon insulation boards and cylinders. Accessories include graphite coatings, adhesives and foils as well as cordage and woven fabrics. For furnace fixturing, fastener, structural and heating element applications, FMI manufactures advanced carbon composites that are up to 10 times stronger than monolithic graphite.

We also fabricate ceramic insulation boards as well as woven blankets, tapes and gaskets.

In addition to developing a reputation for materials ingenuity and fine craftsmanship, FMI offers competitive pricing, off-the-shelf deliveries and extensive technical and engineering support services.

FLINN & DREFFEIN ENG. CO. *(Northbrook, Illinois)*
Booth #506 -- features photographs and brochures which illustrate customed engineered heat processing systems, automatic handling equipment and integrated process controls. Booth attendants will discuss and help solve heat processing applications or conversions of equipment from electrically heated to gas fired-radiant tube heated systems.

FLUXTROL MANUFACTURING, INC. *(Troy, Michigan)*
Booth #100 -- features demonstrations of how flux field concentrators improve induction heating processes. Booth attendants will be available to discuss your particular induction problem and offer guidance on how to properly utilize the Fluxtrol products. The induction heating industry is turning to Fluxtrol to increase production rates, reduce energy consumption and improve heat patterns.

Fluxtrol Manufacturing, Inc. has products designed for all popular induction frequencies on display at this booth along with inductors showing typical applications. An additional display will be devoted to various inductors with metallurgical samples of heat patterns produced by them.

FMJ *(Surrey, United Kingdom)*
Booth #923 -- description not available at time of printing.

FOERSTER INSTRUMENTS, INC. *(Pittsburgh, Pennsylvania)*
Booth #717 -- features Magnatest S, an instrument employing magnetic induction to measure materials properties of metals such as hardness, case depth, alloy and tensile strength. Multiple frequency operation with regression analysis provides unprecedented test accuracy and repeatability. Extremely easy recalibration and set up changes are features of the instrument. Test reports, memory storage, computer interface are integral parts of the instrument.

FUEL CONSERVATION SERVICES INC. *(Newnan, Georgia)*
Booth #833 -- features low thermal mass kiln linings materials.

FURNACE CONTROL CORP. *(Brookfield, Wisconsin)*
Booth #505 -- features the Accucarb probe series. These probes are a new generation of carbon/oxygen sensors developed specifically for the heat treating industry. Applications include: normal carburizing, High temperature carburizing, rotary furnaces, sintering of powder metals and endothermic generators. Microprocessor-based carbon control systems and a uniquely designed Atmosphere Control system for an Endothermic Gas Generator System will also be exhibited.

GAS RESEARCH INSTITUTE *(Chicago, Illinois)*
Booth #333 -- features a private, not-for-profit membership organization representing all

segments of the natural gas industry. Its purpose is to plan, manage and develop financing for a gas-related research and development (R&D) program on behalf of its members and their customers.

GRI will be featuring models photography, and technical papers from its industrial utilization R&D area -- projects such as an Ion-Nitriding Vacuum Furnace.

GAUTSCHI NORTH AMERICA, INC. *(Charlotte, North Carolina)*
Booth #736 -- features heat treating furnaces for the aluminum industry.

G-M ENTERPRISES *(City of Industry, California)*
Booth #232 -- features their "state of the art" vacuum hot zone design including their patented heating element support and locking nozzle.

Information on the new G-M convective heated pressure quench vacuum furnace will be available. In addition, G-M will display standard product lines for aluminum solution treat, hydrogen retort, controlled atmosphere with integral quench, conveyors, and core burnout for the investment casting industry. G-M Enterprises will demonstrate its national service availability in combustion analysis, helium leak detection, instrumentation service and calibration, furnace certification in compliance with all military, aerospace and airframe requirements.

GRANVILLE-PHILLIPS COMPANY *(Boulder, Colorado)*
Booth #740 -- features an improved vacuum gauge. Convectron gauges from Granville-Phillips provde high resolution pressure measurement from atmosphere to 1 millitorr with a single gauge tube and controller. Their wide useful range and highly predictable performance make Convectron gauges an excellent replacement for typical limited range, sow response, drift prone thermocouple and Pirani gauges.

Excellent repeatability helps avoid two problems that may be caused by gauges prone to calibration drift. These are: (1) Product defects if processing is started at too high a pressure. (2) Cycle time delays, the equivalent of downtime, which can result while waiting for a non-repeatable gauge to indicate a desired pressure when the actual pressure is already sufficiently low.

Series 275 Gauge Controllers are available with either digital or analog readout, adjustable pressure set points, extended range to 10^{-4} Torr, and no-display versions for external interfacing and computer control.

GRAPHITE DIE MOLD INC. *(Durham, Connecticut)*
Booth #915 -- description not available at time of printing.

GREAT LAKES CARBON - SPECIALTY GRAPHITE *(Briarcliff Manor, New York)*
Booth #439 -- features machined items of various Specialty Graphite medium and finegrain grades serving the heat treating and materials markets, including heating elements and rods, sintering boats and trays, vacuum furnace guides, and furnace insulation and furniture. Sales and Technical representatives will be available to assist in the selection of proper graphite grades and to discuss specific customer requirements. Specialty Graphite products have been developed that meet challenging requirements associated with new technologies related to heat treating in the aerospace, advanced ceramic, and nuclear industries among others.

GRUENBERG OVEN COMPANY *(Williamsport, Pennsylvania)*
Booth #223 -- description not available at time of printing.

HALMAR/ROBICON *(Columbus, Ohio)*
Booth #409 -- features Halmar/Robicon, who will introduce two demonstration models of their new microprocessor-based SCR Power Control and new 1000Hz Power Supply. The new µP Control provides the benefits of two-way digital communication for centralized process control. The 1000Hz Power Supply eliminates problems associated with harmonics and power factor.

Halmar/Robicon will also display models from the largest selection of standard SCR Power Controls with UL listings and CSA certifications, small 100 and 200 SSR-type Controls and examples of custom-designed controls for special applications.

HAUCK MANUFACTURING COMPANY *(Lebanon, Pennsylvania)*
Booth #601 -- features the SVG Super Velocity Gas Burner, which is designed for a wide variety of applications that benefit from combustion gases recirculation, increased efficiency and improved temperature uniformity resulting from the flame's high exit velocity. The SVG fires any clean industrial fuel gas. The air staging design produces low NOx. The air staging also eliminates thermal shock, allowing the burner tile to remain cool. The SVG operates over a wide range of ratios and pressures, from 30%

excess fuel to cover 3000% excess air. The SVG can operate with preheated combustion air temperatures up to 800F. Burner control may be achieved by pulse firing, cross-connected ratio control or fuel-only control.

HEATBATH CORP.
(Springfield, Massachusetts)
Booth #207 -- features a complete line of metal treating products as well as a patented non-cyanide carburizing salt, a barium-free pack carburizing compound and a non-toxic, water soluble carburizing stop-off compound.

HEAT TREATING MAGAZINE *(Carol Stream, Illinois)*
Booth #741 -- features current issues of HEAT TREATING, the magazine of the thermal processing industry, which will be distributed FREE to attendees. Subscription qualification cards will be available. Business and editorial staff members will be present.

HEAT TREATING NETWORK
(Cleveland, Ohio)
Booth #17 -- features a not-for-profit network of industry, government and academia that identifies, develops and transfers heat treating technology to its industry members and broadly markets the resulting new capabilities.

Visit the HTN booth to learn how you could benefit from the leverage of HTN resources (monetary and personnel) and take a proactive role in the only treating technology transfer organization in the U.S.A.

HESS-MAE, INC.
(Edwardsburg, Michigan)
Booth #432 -- features two Operator-Assisted Straightening Presses. One will be a 40-Ton Conventional Stroke-Controlled machine. The other will be a 16-Ton Electronic Stroke-Controlled machine. The new Electronic Stroke-Controled version offers joystick actuation, three independently adjustable depths, crack detection, automatic anvil selection and automatic depth selection. There will also be a video featuring a microprocessor based automatic straightening system with continuous cycle time optimization. These precise machines offer savings by reducing case depth requirements, therefore, decreasing grinding times, reducing rough sizes, and lowering sludge removal costs. Productivity is enhanced through precision depth control and the addition of automated functions. Two hand operation improves operator safety.

HOLCROFT *(Livonia, Michigan)*
Booth #600 -- features a recognized leader in the manufacturing, selling, and servicing of high-quality furnace equipment. Innovative product designs, with cost-efficiency and customer satisfaction in mind, have propelled Holcroft to the top of the heat treating industry. This pioneering spirit is evident in the equipment we have developed for carburizing, carbon restoration, neutral hardening, tempering, annealing, spheroidizing, sintering, and various other heat treat operations.

Established in 1916, Holcroft specializes in custom and standard furnace designs and offers a commitment to high product standards. Numerous international patents attest to our ability to meet any challenge presented by controled atmosphere heat treatment.

HONEYWELL *(Fort Washington, Pennsylvania)*
Booth #214 -- features control products and systems designed to meet the control and information management requirements for today's thermal processing applications.

Products which are modular and cost effective for both unit process application and optionally as the foundation for integrating thermal process equipment with plant management systems. These include Leaderline Controllers and Recorders, the Series 9000, Loop and Logic Control Systems and Honeywell's new Series 7800 Burner Control System.

HUNTERDON TRANSFORMER COMPANY
(Flemington, New Jersey)
Booth #518 -- features Hunterdon Transformer Company's full range of water cooled transformers, chokes and coils for line and medium frequency induction heating and melting applications at the 1991 Heat Treating Exposition.

The Hunterdon Variable Reactance Transformer (VRT) will be demonstrated. All Hunterdon VRT's are warranted for five years against defects in workmanship and materials, and offer many unique advantages for supplying controlled low voltage and high current power.

HWG INDUCTOHEAT
(Germany)
Booth #408 -- features a demonstration of their their Horizontal Scanner, a compact,

self-contained continuous feed heat treating system for general purpose applications. Exhibit also includes STATIPOWER power supplies for induction heating applications. A STATITRON Transistorized R.F. Induction Power Supply (eliminates oscillator tube) with integral heat station and a UNISCAN II single spindle scanning machine which combines the sub-systems of STATIPOWER 25kHz solid-state inverter, heat station, N.C. scanner and recirculating systems into a single unified structure will be shown. A working operator terminal with diagnostic screen will also be featured.

INDUCTION TOOLING, INC. *(North Royalton, Ohio)*
Booth #725 -- features design and manufacture of specialized case hardening inductor tooling for the Automotive, Heavy Equipment, Bearing and Aerospace industry.

A sister company, Induction Tooling Sales, Inc., is a stocking distributor of FERROTRON®, an induction flux field concentrator made by The Polymer Corporation. Additional affiliations: MSI Automation - Induction robotics, L.C. Miller - RECOIL®; and flexible induction power cables, Zion Industries - Z SCAN®, hydraulic parts handler for induction, and Inductoheat - UNIPOWER® 30 kHz 5-20 kw power supplies.

INDUCTOHEAT, INC. *(Madison Heights, Michigan)*
Booth #400 -- features a broad range of induction heating equipment.

Inductoheat's exhibit will demonstrate their Horizontal Scanner, a compact, self-contained continuous feed heat treating system for general purpose applications. Exhibit also includes STATIPOWER power supplies for induction heating application. A STATITRON Transistorized R.F. Induction Power Supply (eliminates oscillator tube) with integral heat station and a UNISCAN II single spindle scanning machine which combines the sub-systems of STATIPOWER 25kHz solid-state inverter, heat station, N.C. scanner and recirculating systems into a single unified structure will be shown. A working operator terminal with diagnostic screen will also be featured.

INDUCTOHEAT PTY. LTD. *(Australia)*
Booth #404 -- features a broad range of induction heating equipment.

Inductoheat's exhibit will demonstrate their Horizontal Scanner, a compact, self-contained continuous feed heat treating system for general purpose applications. Exhibit also includes STATIPOWER power supplies for induction heating applications. A STATITRON Transistorized R.F. Induction Power Supply (eliminates oscillator tube) with integral heat station and a UNISCAN II single spindle scanning machine which combines the sub-systems of STATIPOWER 25kHz solid-state inverter, heat station, N.C. scanner and recirculating systems into a single unified structure will be shown. A working operator terminal with diagnostic screen will also be featured.

INDUSTRIAL HEATING MAGAZINE *(Troy, Michigan)*
Booth #533 -- features *Industrial Heating* Magazine, which is recognized worldwide as the leading source of authoritative information on thermal technology as it relates to practical applications. *Industrial Heating* is read and referenced by top corporate-level technical directors and management-level engineers who are responsible for the application and control of high temperature heating in primary and processing industries.

INDUSTRIAL HEAT RECOVERY EQUIP., INC. *(El Cajon, California)*
Booth #519 -- features a manufacturer of water cooling systems including Air-Cooled Systems, Closed Evaporative Systems, Open Evaporative Systems and Chillers. The display unit is a compound cooling system to produce cool water for furnace shells, doors and gas coolers while also providing a chilled water source for the diffusion pump and electrical components. This compound system allows an Air-Cooled Heat Exchanger system to be used in all areas of the country to totally eliminate water consumption.

INDUSTRIAL TESTING LABS, INC. *(St. Louis, Missouri)*
Booth #318 -- description not available at time of printing.

INEX INCORPORATED *(Ransomville, New York)*
Booth #436 -- features radiant tubes made of a special composite material (silicon-silicon carbide). These composite tubes offer high temperature capability (up to 2450°F) and exceptionally long life. This new material eliminates the creep (sagging) commonly experienced with nickel/chrome alloys and the thermal shock failures common with mullite radiant tubes. These tubes have been proven to offer superior performance and durability in a wide variety of heat treat processes and atmospheres. A unique, all new patented manufacturing process allows these high performance tubes to be competitive in price with ordinary metal tubes.

INLAND VACUUM INDUSTRIES INC. *(Churchville, New York)*
Booth #317 -- features the industry leader in the manufacture and distribution of high vacuum pump fluids. We have built its solid reputation upon manufacture of the highest quality products, just-in-time delivery, and technical service. Our vacuum pump fluids are carefully distilled through vacuum distillation technology to remove any trace impurities and volatile components that affect ultimate pressure. Our most recent new product, the Inland Excellin high vacuum grease, is an excellent lubricant yet provides lead tight sealing in many vacuum applications. Inland Vacuum aims to deliver not just a product but to deliver the personal attention you deserve. Inland's commitment to customer satisfaction is guaranteed.

INSIGHT SCIENTIFIC INC. *(Simi Valley, California)*
Booth #1T9 (Materials Expo Side) -- features transparent brazing furnaces with advantages in process development and small parts production. Outer tube of furnace is transparent fused quartz with an advanced thin film coating that reflects heat back into the furnace core while simultaneously allowing an unsurpassed view of processes occuring within. The operator can visually monitor the process and make adjustments while it is taking place! Direct monitoring improves efficiency and increases understanding.

Also featured are *Cool Windows* for the furnace OEM and the furnace user. They reflect heat while transmitting visible light, allowing a clear view of the furnace core. This eliminates hot window hazards, decreases O-ring temperatures, reduces cooling requirements, and allows larger windows to be designed into the furnace without creating coldspots in the hot zone.

Insight Scientific also manufactures furnaces for crystal growth, optical fiber drawing, and thermophysical property measurement.

INSPEC *(Carrollton, Texas)*
Booth #217 -- features information on Inspec's newest products, a vacuum carbide sintering furnace and the first in a line of box furnaces. Also featured is a live display of Inspec's Furnace Control System based on the GE Fanuc Line of PLS'S.

INTERNATIONAL TECHNICAL CERAMICS, INC. *(Ponte Vedra, Florida)*
Booth #204 -- features manufacturers of high temperature ceramic coatings and furnace repair materials which reduce fuel costs, increase productivity, and protect equipment. These products are quickly and easily applied by your in-house labor to brick, fiber, refractory, or metal surfaces. Also manufacture unique fiber modules for replacement doors, walls, ceilings, which have outside surfaces that are comfortable to touch. Burner blocks and other custom ceramic products available. Personalized attention given to customer requirements.

IRCON DIV/SQUARE D CO. *(Niles, Illinois)*
Booth #719 -- features Maxline Temperature Monitoring and Control System, which can monitor and control temperatures of one or two separate processes. Allows operation within ranges from 0 to 6500°F, 0.5% accuracy and adjustable response times from 0.025 to 60 seconds. Modline Plus Fiber Optic Infrared Thermometer to measure temperatures from 350°F to 6500°F within 0.75% accuracy. Focusable reimaging lens withstand temperatures of 400°F without cooling. Ideal for difficult-to-reach or obstructed targets.

Also featuring Ultimax Portable Infrared Thermometer for temperature ranges from -50 to 5400°F. Accuracy of 0.5% of indicated value.

JACKSON TRANSFORMER COMPANY *(Tampa, Florida)*
Booth #135 -- features a cross section of "JACKSON QUALITY MAGNETIC DEVICES". Open and encapsulated - water cooled and air cooled - rectangular and toroidal designs, isolation, auto, potential and current Transformers - Reactors - Transinductors - V.I.T. - Integrated Magnetics will be on display.

Design ratings from 5 Va to 15,000 kva - single and three phase - d.c. to 450 khz. The main feature will be a working model of the new (patent pending) JACKSON VARIABLE IMPEDANCE TRANSFORMER "V.I.T." The V.I.T. is an integrated magnetic device which provides reliable and efficient stepless power to such items as electric furnaces, load banks, plating power supplies, etc. Kilowatts of power can be controlled from minute signals of 4-20 milliamps or from 0-10 volts d.c. See ad on page H62.

J. L. BECKER COMPANY *(Livonia, Michigan)*
Booth #328 -- features heat treat equipment and component parts.

JMS SOUTHEAST *(Statesville, North Carolina)*
Booth #632 -- features custom manufacturers of thermocouples and RTD's for heat treating applications. Our thermocouple calibrations include the following types: K, R, S, B, W5, W, J, T, E, and N We offer all types of sheath material from 316 stainless steel to Inconnel to tantalum.

JMS also manufactures high temperature RTD's for temperature up to 1475°F.

JMS also offers special coatings on our sensors or our thermowells for both high temperature applications and for corrosion and abrasion resistance.

Other products include ceramic protection tubes, transmitters, thermowells, wire, and a wide array of industrial temperature measurement instrumentation.

We welcome the opportunity to help you with any applications from standard to unique. Our qualified engineering staff will help you solve any temperature measurement problems.

KINNEY VACUUM *(Canton, Massachusetts)*
Booth #133 -- features the Series 2000 range of mechanical vacuum pumps and systems, which are suitable for use on Heat Treating, Hardening, Melting, Coating, and Metallizing Furnaces.

The new Series 2000 KT-840 will be introduced. This pump of 840 m^3/hr (500cfm), joins the Series 2000 line which also includes 275 m^3/hr (160 cfm) and 505 m^3/hr (300 cfm) pumps. This latest generation of rotary piston pumps have quiet, vibration free operation, force feed lubrication and integral oil mist eliminator, in an attractive, contemporary package. Kinney Vacuum boosters extend capacities up to 22,000 m^3/hr, and with unique Vapor Handling Systems make the most advanced and complete line of mechanical pumps for vacuum furnace applications.

K. J. LAW ENGINEERS, INC. *(Novi, Michigan)*
Booth #618 -- features our complete line of Eddy Current Nondestructive Testing Instruments for Heat Treat Verification, Chemical Composition, Alloy Mix Identification and Surface Crack Detection for Ferrous Metals; and for Conductivity Nondestructive Testing of Non-Ferrous Metals. Introducing the new Verimet® 7000 Computerized Hardness and Alloy Tester. See ad on page H45.

KLOECKNER IONON OF AMERICA, INC. *(Charlotte, North Carolina)*
Booth #319 -- features the latest in Ionitriding and Ioncarburizing equipment. A demonstration unit will show the plasma glow of an Ionitriding System. In addition, actual parts and photographs of installations world wide will be displayed.

Manning the booth will be factory experts who can discuss applications, testing and complete systems. Evaluation and cost estimates will be provided by these gentlemen as they relate to your products.

KOLENE CORPORATION *(Detroit, Michigan)*
Booth #224 -- features Kolene Corporation who, for a half century, has served the metal producing and metalworking industries with innovative technologies for cleaning, descaling and improving the performance of metal components. In the past, our most successful products have emerged from the solving of specific problems. Today, Kolene has expanded the philosophy even further as we seek out new challenges to be met by our more than 50 years of experience and expertise in molten salt bath technology.

This year Kolene is introducing a new, cost effective, cyanide free nitriding process called KOLENE® NU-TRIDE™.

KRAUTKRAMER BRANSON *(Lewistown, Pennsylvania)*
Booth #532 -- features the MIC 2 portable hardness tester and Hocking Eddy Current Equipment for metal sorting and crack detection. In addition, Ultrasonic thickness gauges and flaw detectors will be shown.

KURT J. LESKER CO. *(Clairton, Pennsylvania)*
Booth #206 -- features vacuum pumps, fluids, gauges and hardware, RGA, Gas Sampling Systems.

LECO CORPORATION *(St. Joseph, Michigan)*
Booth #700 -- features the new LECO AMH-100 Automatic Microhardness Tester which combines automatic operation and methodology in conformance to ASTM E384-89. Additional instruments on display include the CM15 Cut-off Machine, PR32 Automatic Mounting Press, VP150/AP50 Semi-Automatic Polisher, Olympus PME-3 Inverted Metallograph, SZ Stereo Microscope, M400-G Microhardness Tester and RT240 Rockwell and Superficial Tester.

New Verimet® 7000

Easy, economical eddy current testing

With the Verimet® 7000, you can quickly monitor the heat treat process for case depth, core hardness or through hardness... without damaging a single part. This new eddy current instrument from K.J. Law Engineers gives you the flexibility of computerized inspection with an easy-to-use software package.

Highlights:

- ❑ "Quick-read" graphics display
- ❑ Minimal operator training
- ❑ In-line, off-line audit or lab inspection
- ❑ Communicates with SPC programs
- ❑ Stores up to 25 different part set-ups

The Verimet 7000 is just one of many K.J. Law solutions to quality inspection challenges. Come see a demonstration at the Heat Treat Exposition.

Booth 618

K·J·LAW ENGINEERS, INC.

NDT Products Division
42300 W. Nine Mile Road
Novi, MI 48375-4103
Phone: (800) 521-5245
Fax: (313) 347-3345

LEEDS & NORTHRUP *(North Wales, Pennsylvania)*
Booth #500 -- features new MICROMAX 2, a small process control system with exceptionally large benefits for heat treaters. For example, MICROMAX 2 standard features include temperature control, ramp/soak programs, carbon potential control, and batch reporting. Also, cycle history stored on hard disk and magnetic tape, and current furnace performance presented on CRT trend displays or on a SPEEDOMAX 25000 Strip Chart Recorder. MICROMAX 2 hardware design puts control processing on the shop floor next to the furnace, with local and remote supervision. Furnace operation can be managed with a MICROMAX 2 Management Station, a personal computer or a MICROMAX 2 Local Station.

LEPEL CORPORATION
(Edgewood, New York)
Booth #414 -- features a wide range of Induction Heating Power Supplies and Equipment. A line of 100% Solid State R.F. Power Supplies. A self contained induction heat treating system for general purpose applications. A new "mini-scanner" for scanning of small parts and "closed-loop" heat exchangers and water recirculators will be displayed.

LEYBOLD INFICON INC.
(East Syracuse, New York)
Booth #703 -- features its full line of vacuum product instrumentation and will demonstrate how it delivers the absolute quality required for heat-treated metals by minimizing contamination in a vacuum furnace. QX2000 RGAs detect contaminants or leaks in the vacuum process environment before these unwanted residual gases cause severe embrittlement, rendering entire loads useless. Leybold Inficon vacuum gauge controllers combine measurement technologies for controlling vacuum furnace pressure from atmosphere through the entire process range. The UL100 PLUS helium leak detector finds even the smallest leaks in vacuum furnaces, assuring maximum up-time.

LEYBOLD TECHNOLOGIES INC. *(Enfield, Connecticut)*
Booth #218 -- features the new Leybold Durferrit GmbH which was formed in April of 1991 by joining the Durferrit heat treat furnace activity of Degussa AG and the metallurgical systems department of Leybold AG.

The new company supplies heat treaters with vacuum furnaces for the brazing, annealing, hardening and sintering of metals and metal powders as well as salt bath and controlled atmosphere heat treat furnaces.

Leybold Durferrit also provides vacuum induction, vacuum arc, electroslag, electron beam, plasma, precision casting and metal powder atomization furnaces to the vacuum metallurgical industry.

LEYBOLD VACUUM PRODUCTS INC. *(Export, Pennsylvania)*
Booth #702 -- features a full range of vacuum pumps and pumping systems for the Heat Treating Industry.

LINDBERG HEAT TREATING CO. *(Rolling Meadows, Illinois)*
Booth #419 -- description not available at time of printing.

LINDBERG, A UNIT OF GENERAL SIGNAL
(Watertown, Wisconsin)
Booth #304 -- features products designed for industrial heat treaters and researchers that are on the leading edge of temperature technology. Specialized Lindberg products like afterburners/catalytic converters can help reduce heat treating emissions on present systems or provide a cost effective alternative to vacuum systems. Also shown will be a new line of laboratory furnaces with patented LGO heating modules incorporating Moldatherm® insulation/element composite.

LIQUID AIR CORPORATION
(Walnut Creek, California)
Booth #904 -- features industrial gases and processes for annealing, neutral hardening & brazing. Processes include the proprietary ALNAT FC system for automatic prevention of decarburization.

Also displaying technology to shorten gas quenching cycles.

Liquid Air is a total gas supplier. Providing nitrogen, aron, hydrogen and helium and now offering on-site PSA/Membrane gas generation systems, FLOAL.

L & L SPECIAL FURNACE CO. INC. *(Aston, Pennsylvania)*
Booth #305 -- features its line of standard and custom heat treating furnaces, ovens, and quench tanks. These include box carburizing and neutral hardening furnaces, tempering ovens, annealing furnaces, batch hydrogen furnaces, car bottom furnaces, shuttle, conveyor, pusher, integral quench furnaces, bell-car furnaces, dual chamber tool room furnaces, tube furnaces (with uniformities up to ± 2°C), top loading furnaces, forging furnaces, box furnaces, agitated

quench tanks, etc. Both gas and electric. All atmospheres are utilized including hydrogen and nitrogen/methanol. Temperatures from 300°F (150°C) to 3100°F (1700°C).

The principles of the company will be on hand to discuss specific customer requirements.

LUCIFER FURNACES, INC. *(Warrington, Pennsylvania)*
Booth #114 -- features a longitudinal half-section of a Dual Chamber Atmosphere Muffle Furnace. This unique display offers the viewer a detailed look at the interior construction of a furnace. The show model is designed with a 10"H x 10"W x 24"L muffle for use with controlled atmospheres in the upper chamber. The lower chamber is complete with a stainless steel liner and fan assembly for circulation and temperature uniformity. Lucifer Furnaces offers the widest selection of Dual Chamber models for use with or without protective atmospheres, while providing the most chamber sizes, temperature ranges, and optional equipment to meet the customer's requirements.

LUXTRON CORP., ACCUFIBER DIV. *(Beaverton, Oregon)*
Booh #827 - description not available at time of printing.

MAGER SCIENTIFIC, INC. *(Dexter, Michigan)*
Booth #327 -- features Mager Scientific, who welcomes you to the 13th Heat Treating Conference. As a supplier to the heat treating industry since 1961, we are proud to be a strong supporter of ASM International.

Mager Scientific is a service oriented supplier of Metallurgical laboratory supplies and equipment. We stock and distribute our own brand of metallurgical lab consumables, Nikon optical equipment and Shimadzu microhardness testers.

In Michigan and Northern Ohio, Mager is the representative for Nikon Instruments. Stop by our booth and see the optical perfection of the New Nikon SMZ-U Stereo and Microphot SA Microscopes. Be sure to pick up one of our metallurgical consumables catalog.

ENJOY THE SHOW!

MAGNATECH, INC. *(Bettendorf, Iowa)*
Booth #440 -- description not available at time of printing.

MANNING U.S.A. *(Morristown, New Jersey)*
Booth #831 -- features a heat treating company that provides technical services and equipment to the power generation, petro chemical, and fabrication industries throughout the world. We offer a wide variety of knowledge and expertise in the field of heat treating by doing a wide array of work at remote locations (on site) or supplying equipment that can be either portable or permanent. The methods of heating used by Mannings U.S.A. are induction, high or low voltage electrical resistance, and high velocity combustion.

MANOIR ELECTROALLOYS CORP. *(Elyria, Ohio)*
Booth #515 -- features new modern alloying techniques to produce TMA Microalloys heat resistant castings such as belts, fixtures, radiant tubes, baskets, retort, drive drums and related furnace hardware with superior resistance to carburization, oxidation, thermal stress and thermal fatigue.

MARATHON MONITORS INC. *(Cincinnati, Ohio)*
Booth #609 -- features their complete line of process control instrumentation, oxygen sensors, and data acquisition software systems. Featured items include: O_2 probe, 3-gas Infrared programmable atmosphere and temperature control systems, vacuum furnace control systems, including a direct pin for pin compatible replacement for the Honeywell 7700. MMI will also feature their complete line of PC based processing modeling, and data acquisition software.

MARYLAND WIRE BELTS INC. *(Church Creek, Maryland)*
Booth #231 -- features the fastest growing metal belt manufacturer in North America. Maryland offers custom made metal belting for use in heat treating, carburizing, sintering, quenching, as well as other material handling/processing applications. Specialties include guaranteed delivery times, which if missed, waive <u>all</u> charges to the customer - the belt is free! Licensed travelling engineers are available to go on site to customer's locations and assist in installation, tracking or belt design. Finally, the "Flat Seat" belt is available which has been time proven to offer the least stretch and truest tracking of <u>any</u> metal belt.

Stop by and pick up information on your free belt.

METAL-LAB, INC. *(Sturtevant, Wisconsin)*
Booth #540 -- features 12 vacuum furnaces (2 of which are Ion Nitriders and 2 others are the most advanced 5-Bar and 6-Bar vacuum

furnaces produced in the world), 25 tempering furnaces, 6 atmosphere furnaces as well as cryogenic capabilities. This state-of-the-art equipment is housed in a modern 33,000 sq. ft. facility that was specifically designed for mold, tool & die and specialized vacuum heat treating. Qualified, knowledgeable and experienced personnel, coupled with the most advanced equipment available, assures that the highest quality standards in the industry are maintained for our customers around the world. Tomorrow's Vacuum Technology Today.

METALLWERK PLANSEE GMBH *(Tirol, Austria)*
Booth #108 -- description not available at time of printing.

METAL TREATING, INC. *(Cincinnati, Ohio)*
Booth #803 -- features custom heat treating of metals - specialists for tools, dies & high speed steel etc. Our processes include salt bath, vacuum, atmosphere controlled batch & continuous production furnaces, deep freeze capabilities of 300°F etc.

METAL TREATING INSTITUTE *(Neptune Beach, Florida)*
Booth #543 -- features the international trade association of commercial heat treating companies comprised of 360 members throughout the United States, Canada, Europe, Central and South America, Taiwan, and South Africa.

Its purpose is to foster a healthy business climate for contract heat treaters. Members benefit via programs geared to the governmental, managerial, marketing, statistical and safety areas in which the companies are involved. Samples of Institute publications and membership information will be available at the exhibit with staff and Institute members who will answer questions.

METRO SCALE COMPANY, INC. *(Melvindale, Michigan)*
Booth #815 -- features a Weight Controlled Furnace Loading System, which utilizes a Three Vibratory Feeder System to control lbs/hour entering the furnace. Controller continuously monitors feed rate to maintain a 99% or better feed accuracy on most parts. Accepts lbs/hour and part information through keypad, remote computer or bar code scanner. Data is logged on a high speed thermal printer and/or remote compauter. Maintains Job/Part Totals. Interfaces to most process controllers. Monitors zone temperatures and belt speeds.

MG INDUSTRIES *(Valley Forge, Pennsylvania)*
Booth #628 -- features advanced furnace atmosphere technology for the Heat Treating and metalworking industries. We offer on-site gas generation plants, bulk storage and distribution systems, and cylinder supply systems. Metallurgical consulting services and engineering assistance are available to customers. Hardware featured at the show will be a PSA nitrogen on-site gas generation system. MG Industries wants to be your "Partner in Technology"!

M.G.P. INC. *(Womelsdorf, Pennsylvania)*
Booth #520 -- description not available at time of printing.

MIKRON INSTRUMENT CO., INC. *(Wyckoff, New Jersey)*
Booth #119 -- features portable and stationary infrared thermometers . . . fiber optic temperature transmitters for non-contact temperature measurement . . . blackbody sources for calibration of infrared thermometers.

MILLER CONSOLIDATED INDUSTRIES *(Dayton, Ohio)*
Booth #324 -- description not available at time of printing.

MKS INSTRUMENTS, INC. *(Andover, Massachusetts)*
Booth #905 -- features vacuum and gas flow measuring/controlling instruments and gas analyzing and detecting instruments at the Heat Treating Exposition in Cincinnati, Ohio on October 22-24, 1991. New products on display include a combination Pirani/cold cathode gauge controller and a quadrupole-based partial pressure transducer. A wide range of Pirani, thermocouple, and hot cathode and cold cathode gauges will also be exhibited. MKS Baratron® absolute pressure transducers are used in processes requiring accurate vacuum measurement and control MKS Mass-Flo™ products are used for the electronic measurement and control of gases from 1 sccm to 200 slm (425 scfh).

MPI FURNACE COMPANY *(Fort Wayne, Indiana)*
Booth #629 -- features a manufacturer and re-builder of Industrial Furnace Equipment with design, in-house manufacturing and field construction capability. Equipment lines include Car-bottoms, Roller Hearths, Tip-Up Furnaces, Belt Furnaces and batch equipment featuring the SUNCASE, SUNDRAW and SUNWASH lines.

MPI is also the supplier of the patented Mark VIII, direct-spark ignited, recuperative radiant tube burner.

The booth display will feature the MPI burner and examples of recent projects completed by MPI.

MVAK TECHNOLOGIES, INC. *(East Hanover, New Jersey)*
Booth #914 -- features a full range of vacuum pump services and products. From vacuum pump rebuilding, to parts and new equipment, MVAK Technologies is the source for vacuum pump services. Visit our booth and experience the quality service and technology you have been looking for.

NATIONAL VACUUM PRECISION *(Malvern, Ohio)*
Booth #340 -- features N.V.P., who offers rebuilding services for vacuum pumps including piston pump, vacuum blowers and boosters, and vane pumps.

We are an authorized service center for Stokes Vacuum and Kinney Vacuum.

N.V.P. also rebuilds the following vacuum equipment: Leybold, Alcatel, Edwards, Welch, Balzers, Roots Dresser, MD Pneumatics, Galileo, Precision, Varian and others.

N.V.P. also manufactures a complete line of vacuum pump oils for these pumps and distributes 702, 704, and 705 silicones for diffusion pumps. Reclamation services for silicone fluids are also available.

Used and rebuilt vacuum pumps for purchase or rental are also available for N.V.P.

NETUREN CO. LTD. *(Columbia, Maryland)*
Booth #642 -- features induction heating equipment.

NEWAGE INDUSTRIES, INC. *(Willow Grove, Pennsylvania)*
Booth #1633 (Materials Expo Side) -- features hardness testing instruments for testing according to the Rockwell, Brinell and Microhardness test methods. On display will be portable, bench and production units all with digital readout, built in statistical software and RS-232 output for printer or computer interface. Of special note will be our MT-90 Production Microhardness Testing System. Capable of doing automatic and fully programmable microhardness tests, the MT-90; can do effective case and decarburization studies in only 2 minutes. Also on display will be our Master Calibration/Hardness Calibration Test Blocks, the only test blocks currently available in the U.S. that offer traceability to esta' 'ished independent international hardness value standards. The highlight of our display will be our new Brinell Optical Scanning System, the B.O.S.S. which is a fully automatic Brinell scope. Available as a PC based or portable hand held unit, the B.O.S.S. automatically reads Brinell impressions, and calculates the impression diameter and Brinell hardness value in under 2 seconds. For over forty years NewAge Industries has been a leader in the field of hardness testing and a stop by our booth will clearly demonstrate why.

NEW WELDUCTION *(Farmington Hills, Michigan)*
Booth #104 -- features its new line of energy efficient ceramic tube oscillators and solid state RF Induction Heating power supplies. A complete Induction Hardening System which utilizes the new products will be on display.

NOBLE INDUSTRIAL FURNACE *(East Windsor, Connecticut)*
Booth #814 -- features pictures, a banner and a small furnace model approx. 2 1/2' high x 2 1/2' round and a few alloy model fixtures to set on a table. The model furnace will also be on a table and will weight approx. 200 pounds. Noble furnace is a manufacturer of heat treating furnaces for the aircraft industry.

OAKLAND METERING LOADERS *(New Baltimore, Michigan)*
Booth #714 -- features their loader for use with belt, rotary and shaker hearth furnaces. The loader has three moving steps designed to reciprocate along a 60° slope. The number of parts discharged from one step to the next tends to become uniform, delivering a practically constant number of parts for each stroke. The loader comes in sizes from six to 96 inches wide. Custom designs are also available.

Used with their integrated designed dumpers and weigh bucket systems, parts flow is maintained at the optimum discharged rate.

OILPURE SYSTEMS *(Rockford, Illinois)*
Booth #911 -- features a purification process, a revolutionary step in oil reclamation technology, that removes contaminants down to submicron size from a wide variety of industrial oil without affecting the additives that protect your process. Additionally, Oilpure Systems reduces emulsified water below 100 parts per million and removes oxidation

by-products. With the capability of purifying 10 to 50 gallons per hour, Oilpure Systems reduces waste handling and new oil purchase costs, lowers equipment maintenance, and meets environmental mandates.

ONSPEC, INC. *(Villa Park, Illinois)*
Booth #920 -- features a full service Contractor with over fifty years of combined experience in all phases of the Heat Treating industry. Our services include installation, conversions, design, including instrumentation, updating, fabrication, modification, troubleshooting, repair and rebuilds onsite or off, process and electrical piping and refractory.

PACIFIC INDUSTRIAL FURNACE CO., DIVISION OF DETREX CORP. *(Southfield, Michigan)*
Booth #508 -- features complete furnace systems for Aging, Annealing, Brazing, Carburizing, Hardening, Hot Forming, Normalizing, Sintering, Solution Treating, and Tempering. Capabilities of complete turnkey installations, computer controlled systems, renovation of existing furnaces, and integrated automation to meet Purchaser's requirements.

Experienced engineers available to evaluate your furnace requirements.

PARK CHEMICAL COMPANY *(Detroit, Michigan)*
Booth #314 -- features Park's complete line of heat treating and aluminum brazing salts, oils, and synthetic quenchants. This year Park introduces the newest additions to our product line - Nocolok® Brazing Flux and Aluminum Casting Salt.

Also featured will be the Holden Furnace Division of Park Chemical Company. Specializing in the manufacturing fo molten salt bath equipment and replacement parts, Holden has had an established reputation in the heat treating business for many years. In order to meet the needs of all heat treaters, the Holden Furnace Division also offers a wide array of quality used equipment.

PARK PRECISION INC. *(Birmingham, Michigan)*
Booth #615 -- features induction heating repair, replacement service, prototype inductor development, complete refurbishing service for all types and makes of induction heating equipment.

PARTLOW/MOLYTEK CORP. *(New Hartford, New York)*
Booth #105 -- features ARC 4100 Analog Circle Chart Recorder, MRC 7000 Microbased Circle Chart Recorder, MIC 8200 Dual Display Temperature Controller, Molytek 2702 Multipoint 32 Channel Recorder, Molytek 3702 Recorder and Molygraphics Full Color Data Acquisition Display Software. New products to be introduced at this show: SIXPAC -- 6 Channel Strip Chart Recorder, ANALINE -- 2 Channel Analog Strip Chart Recorder. See ad on inside front cover of Materials Week section.

PAYNE ENGINEERING *(Scott Depot, West Virginia)*
Booth #808 -- features Payne Engineering who, since 1959, has been recognized for technical leadership in design and manufacturing dedicated to Solid State Motor Controls and SCR Power Controls. They will display the industry's most complete range of these products. Motor controls include: SENTROL EM3 series reduced voltage "Soft Starters", the award nominated 11DZ/EZ Solid State Relays designed to replace mercury displacement switches, and heavy duty series 11R Reversing Starters. Also featured: SCR Power Controls, designed for manual or remote signal operation for complete control in process heating applications up to 1200 amps at 480 volts. Free Literature and Applications Publications.

PENNA-FLAME INDUSTRIES, INC. *(Zelienople, Pennsylvania)*
Booth #804 -- features Case Hardening services. Featured will be the "Uni-Max Case" roll hardening process whereby surface hardening and depth are controlled by computers which allows proof of heat treatment through graphs. Another Penna-Flame advantage is their development of knowing case depth (N.D.T.) utilizing the Penna-Flame Case Depth Meter. On display will be several cross section samples of workpieces which have been certified by testing laboratories.

PILLAR INDUSTRIES *(Monomonee Falls, Wisconsin)*
Booth #639 -- features, among the equipment displayed, a demonstration of induction case hardening of small shafts. This system includes a high frequency induction generator, Lift/Rotate fixture, and automatic robotic loading with complete PLC control.

Beyond conventional heating systems, Pillar designs custom power supplies as well as specialty work handling equipment all engineered to your specific application requirements.

Celebrating over a quarter of a century of pioneering and technology advancements in the

induction industry, Pillar represents the manufacturers interests in quality, profits and customer leadership in their specific area of the industry.

PILLAR INDUSTRIES - MARYLAND DIVISION *(Columbia, Maryland)*
Booth #643 -- features a Vertical Scanning unit with PLC and SPC capabilities and programmable microprocessor. Also an operating equipment Diagnostics system will simulate the ease and quick determination of trouble-shoing production.

Pillar offers both RF and solid-state induction systems and has developed dramatic innovations for meeting the needs of the industry.

Pillar's quarter of a century of pioneering and technology advancements in the induction industry, provides a solid foun-dation that is demonstrated in equipment engineered for quality and reliability.

POLYCARBON INC./SIGRI CORPORATION *(Valenica, California)*
Booth #329 -- features a wide variety of carbon and graphite insulation materials for high temperature applications, including soft felt products and fibergraph rigid graphaite felt. These polycarbon materials are ideally suite l for vacuum furnace appli-caitons. Also on display are Sigri Corporation's product lines, including monolithic graphite and carbon-barbon materials for furnace, furnbiture, heating element, and structural appli-cations. Also available from Sigri are coating materials. Polycarbon, Inc. is a subsidiary company of Sigri Corporation, and the com-bined product lines offer a unique total package of graphite and related materials.

PROCEDYNE CORP. *(New Brunswick, New Jersey)*
Booth #705 -- features advanced gas fired fluidized bed heat treating systems. The patented SJA Heating Mantle, developed under contract to Gas Research Institute, provides heat transfer rates equal to electrically heated mantles and uses twin bed heat recuperating burners for increased energy efficiency. Information on the field test performance, supported by Michigan Consolidated Gas Company will be available at the booth.

Also featured are Procedyne automated fluidized bed heat treating systems that can be incorporated directly into automated manufacturing cells. These systems process multiple parts and multiple heat treatments in a single line and can handle production requirements up to 10,000 pounds per hour.

PROCESS TECHNOLOGY INC. *(Mentor, Ohio)*
Booth #134 -- features the Process Technology line of electric immersion heaters, heating and cooling coils and temperature controls as well as their electonic temperature indicator and amp hour meter. Protec brand heaters and heat exchangers are available in standard and custom configurations.

Customer service personnel are available to offer advice on applications, installation or heater operation. A combined total of 100 years experience can be found in our Sales/Service Department.

PROTECTION CONTROLS, INC. *(Skokie, Illinois)*
Booth #334 -- features a complete line of single and multi-burner PROTECTOFIER Combustion Safeguards for supervision of fuel fired burners.

This type of electronic safety control to monitor fuel fired systems is mandatory to comply with National, State and Local safety codes.

PSI ENERGY *(Columbus, Indiana)*
Booth #625 -- features PSI Energy, Indiana's largest investor owned electric utility serving central and southern Indiana. The industrial sales team of PSI works with its industrial customers and manufacturers of electric process equipment in a partnership to: improve productivity and quality; increase profitability and increase efficiencies through better energy utilization; all of this to maintain a competitive edge for the customer.

PYRONICS, INC. *(Cleveland, Ohio)*
Booth #209 -- features a recuperative indirect fired system that delivers preheated combustion air to a sealed nozzle mix burner providing a burner efficiency in excess of 60%. The system may be supplied with either ceramic or metallic radiant tubes. Stainless and heat resistant tubes meet 1800°F furnace design temperatures for heat treating applications. Silicon Carbide tubes are available for 2300°F furnace processes. This new material provides the benefit of long tube life over a wide range of process temperatures.

Pyronics, Inc. will also exhibit their complete line of burners, regulators and associated combustion and combustion safeguard products.

PYROTEK, INC. *(Trenton, New Jersey)*
Booth #15 -- features insulating materials.

RADIANT HEAT CORPORATION *(Roseville, California)*
Booth #731 -- features a new customized controler for precise control of heat treating systems and processes, controling up to 128 zones with alarms and automatic shutoff features.

RADYNE CORPORATION *(Butler, Wisconsin)*
Booth #624 -- features two vertical scanning systems; a small dual position unit accommodating parts up to 20 pounds and a medium duty unit capable of accommodating parts up to 300 pounds. Both scanners incorporate versatile, flexible and cost-effective control systems, the larger system with user friendly computer control for simultaneous variation of power, speed acceleration and deceleration rates.

Radyne's Quality Assurance system is also shown; the latest version of this popular addition to any induction heating system incorporating online SPC data collection and real time non-destructive testing with system inhibit capability.

RAPID TECHNOLOGIES, INC. *(Newnan, Georgia)*
Booth #830 -- features custom designed gas fired rapid heating forging furnaces.

RICHARDSON ELECTRONICS LTD. *(LaFox, Illinois)*
Booth #810 -- features a leading international supplier of electronic components for industrial applications. They will feature RF tubes for low power dielectric heating applications and high power induction heating applications. The company offers a full range of power triodes ranging from under 1 kW to 450 kW.

Richardson has just added microwave power generators and flying lead RF tubes to its already extensive inventory of electron tubes, power semiconductors and capacitors. Popular types of industrial replacement components will be displayed, including Powerex SCRs; Semtech power semiconductors, Ward Leonard resistors, Amperex, EIMAC, ITT, National and Philips power tubes; M/A-COM, RF Gain and SGS-Thomson RF transistors; and Comet, Cornell Dubilier and High Energy capacitors.

ROLLED ALLOYS *(Temperance, Michigan)*
Booth #129 -- features a major supplier of high performance wrought heat and corrosion resistant alloys to industry. Their exhibit pictorially reviews several applications in which their alloys are used. Additional information on their alloys, the pictured applications plus many more is available from their exhibit representatives.

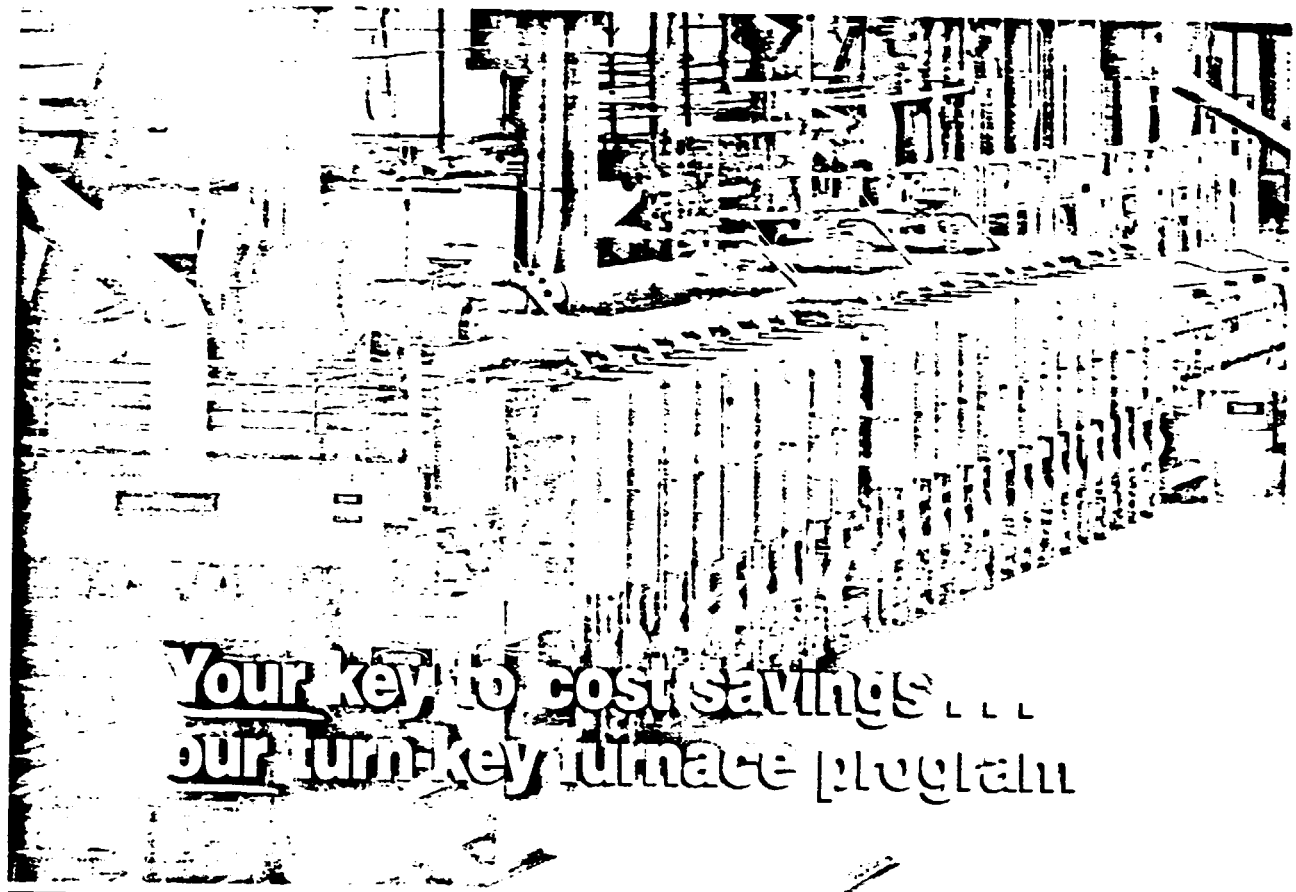
ROLOCK/CALALLOY *(Fairfield, Connecticut)*
Booth #308 -- features a wide range of nickel-base alloy fabrications such as muffles, retorts, lift post fixtures, serpentine trays, work carriers, special fixturing, mesh screens & trays, samples of vacuum liner rebuilding techniques, lightweight molybdenum fabrications, heating elements, atmosphere equipment and thermocouple assemblies.

SALEM CORP. *(Pittsburgh, Pennsylvania)*
Booth #819 -- features Salem, who is widely known for providing engineering services and equipment of the highest quality. They will introduce a Short Time Cycle (STC) Furnace offering high production and quality stabilization. The multi-purpose, fully automatic and energy-saving Salem-Daido STC Furnace performs full annealing, stress relief and carbon restoration. It processes steel wire coil, wire rod coil, bar, pipe and parts for cold forging.

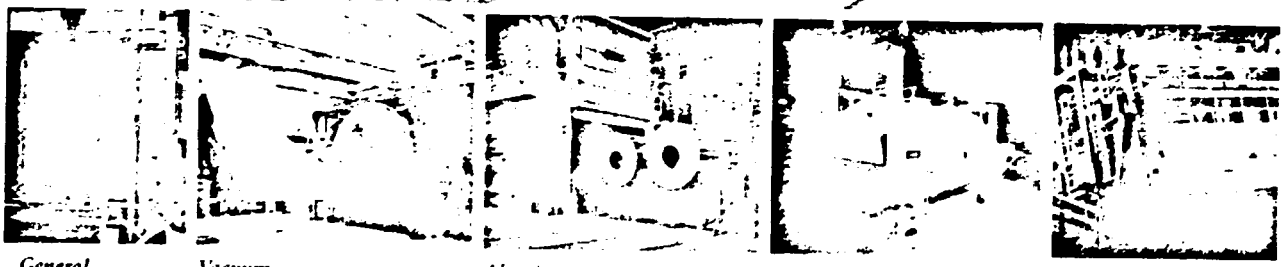
Salem also designs, constructs and installs monitoring and control systems for the processing industries. Configurations range from personal computer based to large hierarchical integrated systems. The software system can be custom-designed and programmed to fit a customer's needs.

SANDTEX INC. *(Union City, California)*
Booth #901 -- features high temperature textiles. The SANDTEX and COOPERKNIT fabrics are strong and flexible and are truly unique in providing thermal insulation in a wide variety of high temperature applications. The Knitted construction of COOPERKNIT allows complete flexibility in insulation design, conforming to flat or curved surfaces and other complex shapes that require thermal insulation.

The COOPERKNIT cloths offer an excellent alternative to asbestos and other insulation materials and can be used without the health and hygiene precautions that are frequently mandated when using these products.



Your key to cost savings . . .
our turn-key furnace program



General Furnaces | *Vacuum Furnaces* | *Aluminum Furnaces* | *Die Casting Furnaces* | *Nonferrous Melting Furnaces*

Seco/Warwick Furnaces

For nearly a century, Seco/Warwick industrial heat processing furnaces and systems have served as the standard of excellence worldwide. Those familiar with the heat processing industry acknowledge Seco/Warwick as the finest custom engineered furnaces in the world.

Today we offer cost savings in all types of heat processing furnaces through our turn-key furnace program. We'll design, engineer, build and install complete systems including state-of-the-art computerized control systems. It's single source responsibility at considerable savings to you.

We produce virtually every type of heat processing furnace: general atmosphere, vacuum, aluminum process, nonferrous melting and a full line of auxiliary equipment including atmosphere generators.

If you want complete satisfaction in your next furnace, specify Seco/Warwick. We'd like to be part of your team.

Write for our new Custom Engineered Furnace Systems brochure . . . or call **814-724-1400.**

Seco/Warwick Corporation
400 Mercer Street
Meadville, PA 16335 USA
Fax: 814-724-1407

SECO/WARWICK

COOPERKNIT, an amorphous silica knitted fabric, can be used at steady state temperatures up to 2000 degrees.

SBS CORPORATION
(Rochester, Michigan)
Booth #300 -- features SBS Corporation's introduction of its revolutionary "Sludgebuster" quench oil cleaning systems. Also featuring our complete line of process control equipment including heating, cooling, circulating and cleaning of quenchants.

SECO/WARWICK *(Meadville, Pennsylvania)*
Booth #415 -- features a company with nearly a century of experience designing and building industrial heat treating, processing, and melting equipment. Seco/Warwick Corporation will be graphically displaying some of its more impressive furnace systems. These systems include aluminum process furnace systems, vacuum furnace systems, general heat treating furnace systems, and melting furnace systems.

Custom engineered roller hearth furnace systems will be highlighted as will custom designed and programmed computer control systems. From start to finish, Seco/Warwick will highlight its turn-key furnace program which includes installation and start-up, troubleshooting, and equipment maintenance. See ad on page H53.

SENTRY EQUIPMENT CORP.
(Oconomowoc, Wisconsin)
Booth #806 -- features Plate Heat Exchangers and Packaged Cooling Water Systems. A standard 100 KW system will be on display to demonstrate the space savings provided by Sentry's compact Brazed Plate Exchanger. Sentry concentrates on the OEM market and offers same day quotations of custom designed heat exchangers.

SHELER CORPORATION
(Sterling Heights, Michigan)
Booth #733 -- features Induction Heat-Treat Tooling -- Inductors and Related Equipment; New (any make); Rebuild (any make); Complete Design and Redesign Service; Consultant Service; Transformers (any make); Billet and Forging Coils; 24-Hour Emergency Service. We warranty our Rebuilds to get the same production life as our New Inductors. Quality and Service At A Fair Price Since 1960.

SIEMENS COMPONENTS, INC. *(Iselin, New Jersey)*
Booth #219 -- features an extensive line of generator tubes including the new "Mega Power" Generator Tube (Model # RS 3700 CJ), a new water cooled Metal-Ceramic triode for frequencies up to 30 MHz, producing oscillator power up to 1.25 Megawatts. Power ranges from 1.9 KW to 1.25 Megawatts provide flexibility in selecting the most appropriate power for a specific application. Available from stock, the tubes are offered with a pro-rated, one year or 4,000 hour warranty.

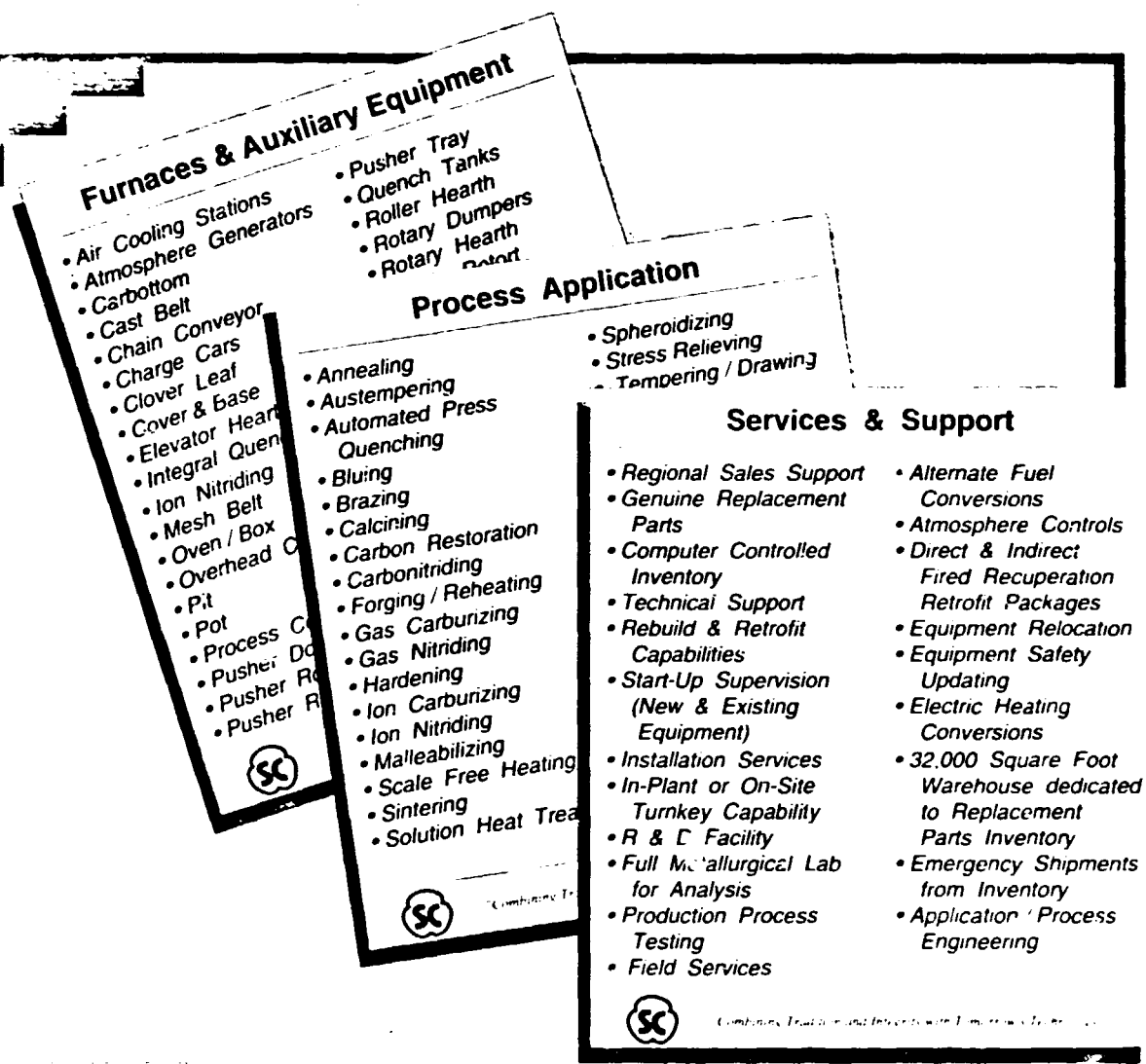
SIEMENS ENERGY & AUTOMATION, INC.
(Alpharetta, Georgia)
Booth #800 -- features Process Gas Analyzers for measuring furnace atmospheres and environmental emissions. ULTRAMAT 5 and ULTRAMAT 21/22 models utilize advanced NDIR (Non Dispersive Infrared) technology for measuring CO_2, CO, CH_4, NH_3, etc. to insure proper monitoring of heat treating atmospheres. Both units feature the patented Siemens micro-flow sensor for excellent sensitivity and the double layer detector for high selectivity in the presence of interference gases. OXYMAT 5 offers a unique application of the paramagnetic Quinke principal for O_2 analysis. The analyzer has no moving parts and the sensor is never in contact with the sample gas.

SIERRA VICTOR CO., INC.
(St. Charles, Illinois)
Booth #311 -- description not available at time or printing.

STANWOOD CORPORATION
(Oak Creek, Wisconsin)
Booth #501 -- features Stanwood Corporation, a manufacturer of heat and corrosion alloy fabrications and castings. As a supplier to the heat treating industry, Stanwood offers furnace replacement parts such as fans, radiant tubes, muffles and retorts as well as rod baskets, corrugated boxes, serpentine and/or cast trays and fixtures.

STOKES VACUUM INC.
(Philadelphia, Pennsylvania)
Booth #614 -- features Model 615-BP high vacuum blower which incorporates an automatic recirculating by-pass with the field proven Stokes 615 blower -- This by-pass allows the blower to start from atmosphere -- thus resulting in significant reduction of pumpdown times. Also on display will be two models of the new Windror vane pump line ranging in size from 1.5 to 7.4 cfm. In addition, a new solid state control panel specifically designed for mechanical booster systems will be available.

SURFACE COMBUSTION, INC. *(Maumee, Ohio)*
Booth #228 -- features a celebration of 40 years of technical and market leadership by the Allcase® Batch Ingetral Quench Furnace. A model of the Ultracase®, the latest technology in this family of furnaces will be



Surface Combustion, Inc. is not just a furnace supplier to the metals industry. From the initial contact with our dedicated sales engineers through our extensive aftermarket support, Surface offers a variety of services to help our customers maximize the value of their capital investment.

Surface has one of the most diverse product offerings in the industry. Since Surface manufactures such a wide range of batch and continuous systems, we propose equipment only after carefully comparing quality, metallurgical, and production requirements with the various process, material handling, and equipment alternatives available.

Surface has been a leader in high temperature processing technologies for over 75 years. Continued dedication to research and development offers our customers access to extensive lab and technical capabilities, as well as the latest trends and advancements in thermal processing.

Contact Surface for all your thermal processing requirements.

Surface Combustion

1700 Indian Wood Circle
P.O. Box 428
Maumee, Ohio 43537-0428
(419) 891-7150
FAX (419) 891-715

displayed. A video presentation will feature the Allcase in addition to providing background on Surface Combustion's history, experience, capabilities (engineering, manufacturing and service) and products. Photos and literature of equipment including Allcase, vacuum, ion, continuous, batch furnaces and atmosphere generators will be shown and available. An extensive array of Surface's control systems will also be available for demonstration. See ad on page H55.

TELEDYNE HASTINGS-RAYDIST *(Hampton, Virginia)*
Booth #21 -- features the Model HVM-272 which is a new Digital Thermocouple Vacuum Gauge with a range of either 0-20 TORR or 0-20 millibar. The unit is packaged in a 1/8 DIN module and incorporates a 3-1/2 digital LCD readout. An optional mounting kit is available to allow mounting of the instrument in an existing panel cutout for a Hastings Model VT Vacuum Gauge.

The small, reliable gauge tube uses the time-tested Hastings thermopile sensor for optimum accuracy and stability.

TELEVAC DIVISION OF THE FREDERICKS CO. *(Huntingdon Valley, Pennsylvania)*
Booth #202 -- features a modular vacuum gauge with either analog or microprocessor-based digital displays.

Televac is presenting a new modular vacuum controller which incorporates integrated modules for measuring a wide pressure range. Modules are interchangeable between the analog and digital version and can be replaced without removing the instrument from its mounting. Up to 12 stations of measurement are possible. The digital version has RS232 communication and microprocessor control.

TENAXOL INC. *(Milwaukee, Wisconsin)*
Booth #401 -- description not available at time of printing.

THE CARBORUNDUM COMPANY *(Niagara Falls, New York)*
Booth #906 -- features two product lines from Carborundum electronic materials and structural ceramics group.

Globar® silicon carbide heating elements provide even heat to 3000°F. Widely used for over 60 years these elements are adaptable to many designs. Three piece construction has center heating section while cold ends allow efficient connection points. Hexoloy® silicon carbide furnace components provide unusual resistance to high temperatures.

THE FURNACE BELT CO. LTD. *(Mississauga, Ontario, Canada)*
Booth #825 -- description not available at time of printing.

THE KANTHAL CORP. FURNACE PRODUCTS DIVISION *(Bethel, Connecticut)*
Booth #509 -- features Molybdenum disilicide heating elements, Silicon Carbide heating elements, iron-chrome-aluminum products wire and strip heating elements. APM, Superthal and high temperature radiant tubes.

THE METAL WORKS INDUSTRIAL FURNACES, INC. *(Oak Park, Michigan)*
Booth #121 -- features information on the types of heat treating equipment they manufacture, including salt bath, atmosphere and fluidized bed furnaces. There will also be information on data acquisition and Data Record 'n Plot. Members of The Metal Works will be on hand to demonstrate Data Record 'n Plot and answer any product questions. See ad on page H57.

THERMAL-BASIC, INC. *(South Windsor, Connecticut)*
Booth #538 -- features Continuous Mesh Belt Heat Treating Systems, Batch and Continuous Annealing Furnaces, Brazing Furnaces, Sintering Furnaces, Austempering Systems, Pit Furnaces, Batch and Continuous Parts Cleaning Systems, Atmosphere Generators and their new Multi-Belt & Multi-Hearth Dedicated Heat Treating Systems for Cellular and JIT Manufacturing.

Also featured will be the rebuilding, redesigning and upgrading of existing equipment and control systems.

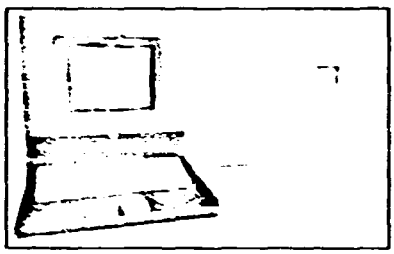
THERM ALLIANCE CO. *(Detroit, Michigan)*
Booth #718 -- description not available at time of printing.

THERMAL TECHNOLOGY INC. *(Santa Rosa, California)*
Booth #907 -- features furnace systems for high temperature materials processing and development.

Refractory metal furnaces reaching 3000°C or 10^{-9} torr are available for high purity testing, materials development, brazing, co-firing and heat treating.

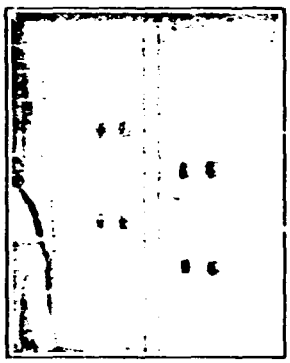
Graphite furnaces for operation to 2800°C or higher are used for CVD, sintering, reaction bonding, and graphitizing.

THE BEST THING TO HAPPEN IN CREATIVE DESIGN SINCE Da VINCE IS HAPPENING AT THE METAL WORKS TODAY!



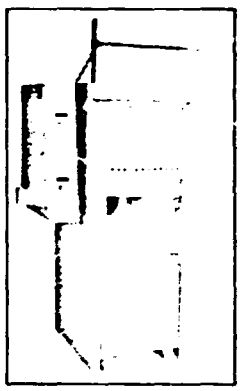
"DATA RECORD 'n PLOT"

For design, estimating, data analysis, industrial and environmental condition monitoring and control, SPC and CAD applications it is Data Record 'n Plot™. Data Record 'n Plot, an Apple Macintosh® compatible computer, gathers, records and plots data such as cooling curves over TTT diagrams. Data Record 'n Plot also controls, furnaces, motors, fans, liquid flow, atmosphere, etc.

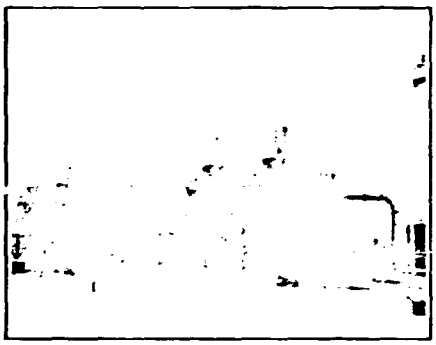


VERTICAL ELECTRODE SALT BATH FURNACES

Automated or batch, atmosphere, salt or fluidized bed THE METAL WORKS *has a heat treating system designed to keep you ahead of the competition.*

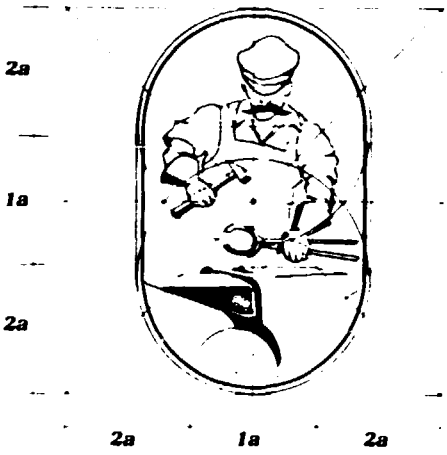


ATMOSPHERE FURNACES



TOTAL ENVIRONMENTAL CONTROL SYSTEMS

In furnace and computer systems, the blacksmith is your assurance of a quality product from THE METAL WORKS.



If your heat treating system designs are not as creative as your product requires, they may create all sorts of problems.

The beauty of a system from THE METAL WORKS ***is that our designs match your requirements at a price that won't cause you problems!***

Naturally, we offer a large variety of atmosphere and salt bath furnaces and systems.

So, when you choose your next heat treating system call on the creative designs of THE METAL WORKS.

A video review of a system from THE METAL WORKS ***is available upon request.***

Join us at the ASM Heat Treating Conference at Booth #121

THE METAL WORKS *Industrial Furnaces Inc*

21100 Fern, Oak Park, Michigan 48237

(313) 545-6700 FAX (313) 545-5472

... the perfect blend of tradition and technology

Silicon carbide and moly dieilicide furnaces for temperatures up to 1900°C are available for development and testing of oxide based materials.

Thermal Technology is the recognized leader in the design and manufacture of very high temperature laboratory, research and development, and production furnace systems.

THERMCO INSTRUMENT CORPORATION *(LaPorte, Indiana)*
Booth #742 -- features their gas mixing system for furnace atmospheres. The Thermco gas mixing system for hydrogen/nitrogen features digital hydrogen analysis and the necessary alarms and controls to meet the latest NFPA 86C standards. The Model 8300 for 0-2000 SCFH flowrate will be on display. Thermco will also display their portable and stationary gas analyzers for measuring hydrogen.

THT DIVISION, DOWA MINING CO., LTD *(Tokyo, Japan)*
Booth #716 -- features Japan's leading manufacturer of gas carburizing furnaces. They will be exhibiting ZEROTIME hardening and FINE CARBO® for gas carburizing applications. Separate chamber-type continuous furnaces omit the cooling zone of conventional straight-through furnaces, replacing it with a separate chamber with enhanced atmosphere control, superior temperature uniformity, minimum part distortion, and shorter cycle times.

FINE CARBO® is a completely new gas carburizing process which produces a strongly active carburizing gaswithin the furnace chamber itself, replacing the need for an endothermic generator or nitrogen/methanol system. Carburizing time is reduced. Operating cost is less, and fatigue strength of parts is enhanced.

T-M VACUUM PRODUCTS INC. *(Cinnaminson, New Jersey)*
Booth #822 -- features a full line of high vacuum furnaces, vacuum ovens and custom systems. The "high tech" vacuum furnaces are packaged fully integrated microprocessor control systems. Standard horizontal furnaces (2400°F) and laboratory vertical furnaces (to 4000°F) are basic manual systems. The tool room furnace with gas quenching is automatic.

Hot wall oven systems up to 600°C as standard, custom designed systems and shelf ovens are available.

Standard hot wall vacuum ovens - horizontal or vertical - provide temperatures up to 600°C and sizes to 16 cu. ft. Custom designed special or shelf heated systems are available.

Additional products include standard and custom glove box systems, gas purifiers and controls for assembly and/or welding.

TOCCO, INCORPORATED *(Madison Heights, Michigan)*
Booth #120 -- features the unveiling of a new generation of INDUCTRON microprocessor-based, solid state power supplies at the Heat Treat Show. These voltage-fed power supplies deliver from 1 to 10 kHz with power output from 30 to 1,000 kW. TOCCO's new user-friendly control features built-in diagnostic routines, visual display operator prompting and RS-232 compatibility with off-line computer systems. System features can be tailored to individual customer control needs.

TOCCO also will demonstrate a new self-contained vertical scan induction heat treating system in Cincinnati. This compact system incorporates a microprocessor controlled INDUCTRON power supply, TOCCO track scanner and quench recirculating and cooling system on a common base. TOCCO's patented TPH gear profile hardening system also will be demonstrated.

TOCCO DIVISION *(Madison Heights, Michigan)*
Booth #116 -- features TOCCO "QUALITY PLUS" services for induction heating, that includes new replacement part manufacturing, repair field service, JIT programs, laboratory process development, commercial heat treating, metallurgical services, and equipment training.

TOTAL TRAC SYSTEMS INC. *(Albany, Indiana)*
Booth #325 -- description not available at time or printing.

TRANSMARES CORPORATION *(Carteret, New Jersey)*
Booth #342 -- features EITEL RP-25 Straightening Press with advanced PSC servo-hydraulic stroke control for straightening shafts, tubing, flat stock, etc. Capable fo handling up to 120 parts per hour with a TIR within .003". Equipped with a patented control, permitting to set the ram stroke to the exact bending depth required, eliminating the hit-or-miss technique typical of pressure controlled straightening and can be expertly handled by unskilled operators. This feature virtually eliminates waste or breakage of hardened parts, inhibits overbending, and expedites production.

WOLTER Automatic Crack Detection Unit for automatic detection of cracks during straightening, thus eliminating the need to magnaflux.

TRITON SOFTWARE, INC. *(Glen Mills, Pennsylvania)*
Booth #9 -- features the Triton Heat Treat Control and Information System. This advanced networked heat treat control system from Triton Software, Inc. effectively combines supervisory control, operator interface, and relational database processing. The system offers thermal recipe management, real-time and historical trending of load TCs or PVs, historical job records, and alarm handling. It uses a distributed real-time multi-tasking operating system to control and acquire data from the process. This allows all key personnel, from management through operations, to simultaneously access real-time and historical information via local and remote computers.

Powerful, yet user-friendly, the Triton System features high-resolution color graphics, pop-up windows and one-key-stroke commands. Trends can be seen in zoom or pan views with real-time temperature data displayed concurrently with the setpoint profile. Setpoint profiles may be created from recipe generation screens with unlimited numbers of ramp, soak, cool, and quench segments. A simple "English-like" Recipe Language takes the confusion out of programming single-loop controllers.

The database uses a standard Structured Query Language (SQL) interface so that complete historical job information can be quickly recalled and reports, easily generated. The system platform uses IBM or IBM compatible personal computers and may interface to single-loop controllers and PLCs from a variety of manufacturers.

ULVAC SINKU RIKO, INC. *(Kennebunk, Maine)*
Booth #541 -- features two of the Sinku Riko broad ranges of thermal instruments and related products available for use in research, development and production of materials.

- QHC-P610-C Infrared Gold Image Laboratory Furnace - for very precise rapid heating and cooling of specimens to 1300°C in clean environments.
- MS-E1-S/10 Mircoscope High Temperature Heating System - for observation of surface phenomena to 1500°C using a gold image furnace as the heat source.

Other laboratory and larger scale applications of these energy and time saving infrared Gold Image Furnace Systems, using parabolic and elliptical reflector arrays, will be illustrated.

UNION CARBIDE INDUSTRIAL GASES INC. *(Danbury, Connecticut)*
Booth #131 -- features Linde's total gas supply, technology, and service for the heat treating industry. Linde's nitrogen supply capabilities include the NitroGEN membrane systems, which provide gas up to 99.9995% oxygen-free. A membrane unit is displayed. Representatives are available to discuss supply and flow control systems for hydrogen, argon, helium, methanol, and propylene for furnace atmospheres. Personnel are also on hand to discuss Linde's technology for atmosphere processes, atmosphere stabilization, fluid bed and vacuum furnace quenching. Linde services include system design, field engineering support, process evaluation, trouble-shooting, and R & D assistance.

UNITED TESTING SYSTEMS, INC. *(Woodstock, Georgia)*
Booth #809 -- features the following:

1) A UHT-10 Tru-Blue Hardness Tester with "Smart" Tru-Blue SPC software package.
2) A URF-1 Tru-Blue "rockwelfit" conversion package for semi-obsolete hardness testers.
3) A SFM-30 "Smart 1" Computer Controlled Universal Testing Machine.

UPTON INDUSTRIES, INC. *(Roseville, Michigan)*
Booth #514 -- features Upton equipment photographs and product literature on molten salt bath furnaces, specialty furnaces, metal finishing systems, and automation part handling systems. Key management and engineering personnel will be available to discuss various types of heat treating, brazing, descaling, paint stripping, and metal finishing equipment.

VAC-AERO INTERNATIONAL INC. *(Oakville, Ontario, CANADA)*
Booth #524 -- features manufacturers of high technology vacuum furnaces including both vertical and horizontal gas quenching, aluminum brazing, vertical direct oil quenching (highlighted in exhibit video) ion nitriding custom designs. Retrofits, and associated ancillary equipment.

VACUUM FURNACE SYSTEMS CORPORATION *(Souderton, Pennsylvania)*
Booth #1734 (Materials Expo Side) -- features a new horizontal Model HL36BH Vacuum Furnace. This furnace will show a different approach in the design of a round graphite hot zone and an external "combined can" blower/heat exchanger arrangement. The new design will improve cooling efficiencies and will be easier to maintain.

VACUUM RESEARCH CORP. *(Pittsburgh, Pennsylvania)*
Booth #208 -- features low cost digital Pirani and diaphragm gauges for pressures from 10-5 Torr to 1500 Torr and 200 PSIG. Aluminum gate and angle valves with ports from 2 inch to 36 inch. ANSI, ISO JIS and QF flanges available.

Totally oil free roughing pumps. 16 and 32 CFM with ultimate pressure of 10 millitorr.

Low cost recorders for temperature pressure and vacuum. 4 inch and 10 inch charts. Optional digital display.

Complete line of Panel meters, current transformers and portable test equipment beckman, H-P, Yew and CGS Thermo T/cs.

EIL Test Equipment. See ad on this page.

VACUUM TUBE INDUSTRIES, INC. *(Brockton, Massachusetts)*
Booth #438 -- features photographs of reconditioned induction heating units and rebuild oscillator tubes.

VORTEK INDUSTRIES LTD. *(Vancouver, British Columbia, CANADA)*
Booth #734 -- features Whitelight™ Surface Treatment for the first time in North America. Large-area surface melting and heat treatment are achieved by an intense beam of light from a powerful lamp. Case hardening, consolidation of powder coatings and surface remelting of cast iron will be displayed. Engineering

staff will be on hand to discuss details of the Whitelight™ process and its application to specific jobs. Performance and cost comparisons to flame, induction, e-beam and laser treatments will be shown.

WALL COLMONOY CORPORATION *(Madison Heights, Michigan)*
Booth #909 -- features contract services in heat treating and brazing, plasma and thermal spraying, and precision machining and fabrication. Facilities in the U.S., Canada and Europe operate some of the largest commercial, protective atmosphere furnaces (including vacuum), up to 120 inches in diameter.

Also featured will be Nicrobraz® products for high-temperature brazing, including nickel base filler metals in powder, paste, sheet, transfer tape and rod form; applicator systems; and brazing stop-offs, fluxes, and blasting grit.

Wall Colmonoy offers a three-day course in "Modern Furnace Brazing". Held twice a year, the next workshop in Nov. 12-14, 1991. The course instructors are led by Robert L. Peaslee, American Welding Society Fellow, inventor of nickel base brazing, and 1991 recipient of the Comfort A. Adams Award.

WALMIL COMPANY *(Troy, Michigan)*
Booth #724 -- features design and manufacture of heat and corrosion alloy fabrications. Furnace equipment includes complete product line of radiant tubes, recuperators, regenerators, heating elements, muffles and retorts. Metal processing equipment includes complete product line of rod frame baskets, corrugated boxes, serpentine trays and fixtures and phosphate barrel assemblies. Repair programs for furnaces and processing equipment. Engineering and manufacture of automated loading systems. Equipment includes product line of Walmil Ram Loaders and Walmil Parts Dumpers, enhanced with optional computer controlled weight systems.

WATLOW *(St. Louis, Missouri)*
Booth #917 -- features Watlow's ramping controls with data logging capability. The Series 942 1/4 DIN control represents the company's newest addition to its thermal system component line offered to the heat treating industry.

To demonstrate the control's ramping capability, it will be connected to a serial printer tracking setpoint and process variables. A master/slave control configuration will also be showcased.

Other Watlow thermal system components to be displayed include a variety of powerful industrial heating elements with capabilities to 2200°F; SCR power controllers, and Watlow Gordon's temperature measurement products, including mineral insulated thermocouples and bulk wire.

The new Watlow Gordon product catalog will be given free to show visitors.

Engineers will be available to assist visitors with integrating each Watlow component into a successful heat treating system.

WAUKEE ENGINEERING COMPANY, INC. *(Milwaukee, Wisconsin)*
Booth #227 -- features the New Nitrogen-Methanol System for precision control of Nitrogen and Methanol used to make synthetic Endothermic gas within heat treating furnaces. The Waukee Nitrogen-Methanol System offers a complete diagnostic package indicating normal and abnormal process conditions. The system also incorporates automatic purge cycles, easy set-point control and four run modes. The system is easily integrated with additive gas control systems, auxiliary alarms, data loggers, chart recorders and other data acquisition equipment.

Also featured will be the Waukee-Tronic and Valve-Tronic electronic Flo-Meter and flow control valve, compressors, mixors and the "Heat Treaters Friend", the complet eline of Waukee Flo-Meters.

WEAVER INDUSTRIES, INC *(Denver, Pennsylvania)*
Booth #820 -- features machined graphite and carbon. Custom molded urethane.

WILLIAMS CO. INC. *(Pittsburgh, Pennsylvania)*
Booth #605 -- description not available at time of printing.

WILLIAMSON CORP. *(Concord, Massachusetts)*
Booth #902 -- description not available at time of printing.

WILSON² INSTRUMENTS, INC. *(Binghamton, New York)*
Booth #708 -- features Wilson Instruments who will be celebrating 70 years in the materials testing industry this year with several new products to be featured. Wilson products will range from their new Microficial II Hardness Tester and Portable Brinell Hardness Tester to their most recent designs in Rockwell Hardness Tester, Tukon Series 200 Microhardness Testers, the Automatic XY Traversing Unit and Hardness Test Blocks and accessories. All Wilson hardness testers completely conform to

ASTM Standards, your assurance of the most precise calibration standards in the world.

WIRCO INC. *(Avilla, Indiana)*
Booth #912 -- description not available at time of printing.

WOLFSON HEAT TREATMENT CENTRE *(Birmingham, England)*
Booth #215 -- features England's focal point for information, advice and education on all aspects of industrial heat treating. Wolfson Heat Treatment Centre will highlight its publications now available worldwide. These include the internationally-renowned quarterly "Heat Treatment of Metals", the only British journal devoted exclusively to industrial practice and innovation, and the series "Guidelines for Safety in Heat Treatment".

WORCESTER POLYTECHNIC INSTITUTE *(Worcester, Massachusetts)*
Booth #117 -- features Worcester Polytechnic Institute's Center for Intelligent Processing of Materials. They will be announcing the formation of a new Laboratory of Carburization Heat Treatment Studies. The new effort will focus on the development of a novel model-based adaptive control system for a wide variety of industrial carburization heat treatment processes. The interactive computer model will be available at the Heat Treat Expo for your examination and testing.

ZEDMARK DIV. QUIGLEY CO. *(Dover, Ohio)*
Booth #539 -- features the Company's line of Refractory products including Fireclay, Hi-ALumina, Insulating Brick and Fired Shapes. Also featured will be Zedmark's new line of Monoliths Products including Low Cement Castables, Conventional Castables, Lightweight Castables, Gunning Mixes, Mortars, Patches and Ramming Products.

ZIRCAR PRODUCTS, INC. *(Florida, New York)*
Booth #112 -- features a manufacturer/fabricator/International marketer of high performance, high temperature fibrous ceramic, thermal, electrical and structural insulation products. These products consist of various fiber types such as Zirconia, Alumina, Alumina Silica and other Refractory Oxide compositions. Product shapes include fibers, powders, papaers, felts, cloths, composite shapes, engineered insulation assemblies, heating elements and accessories are also available.

ZIRCAR's products are used in various industries. Some applications include: furnaces, electrical components, battery separators, sensors, lasers, reactors, lighting, and other specialized applications.

ATMOSPHERES AND GENERATORS

Atmospheres

Gas Generators

Nitrogen/Nitrogen-Methanol

COMPOUNDS AND SOLUTIONS

Cleaning Solutions/Compounds

Quenching, Oils

Quenchants, Synthetic

Salts, Heat Treating

FURNACES AND HEAT SYSTEMS

Atmosphere Furnaces (Gas Fired, Oil Fired, Electric)

Batch (Box) Furnace

AUXILIARY EQUIPMENT AND SUPPLIES

Controls, Fuel/Air Ratio

Controls, Temperature

Fixtures

Freezers/Chillers

Furnace Parts (Fans, Radiant Tubes)

COMMERCIAL HEAT TREATING SERVICES

Heat Treating

Testing

Others