Plenary Address: The Impact of Energy Availability and Pollution-control Regulations on the Ferro-alloy Industry

by W.H. MAGRUDER* (presented by Mr Magruder)

From its earliest beginnings in the late 1800s, the ferro-alloy industry (and, because of its close relation and history of facility interchangeability, I choose to include calcium carbide in this category) has been characterized by its energy intensity.

Although considerable success was achieved with the production of ferromanganese in blast furnaces before 1900 (and much of the world's ferromanganese is still produced in this fashion), the real origin of the ferro-alloy industry, and its dominant tool – the three-phase submerged-arc electric furnace, as we know it today – coincides with the turn of the century. The production of calcium carbide and ferro-alloys in small single-phase furnaces (evolving from Siemens' initial work in 1879) gradually gave way to larger-scale production in three-phase units, many of which incorporated the continuous self-baking electrode invented by Söderberg in 1909. By World War I, a mature industry existed in Europe and North America, and by the end of World War II it had expanded to most industrialized nations of the world. Furnaces have now grown from early twentieth-century 500 to 1000 kVA levels to today's typical new 30 000 to 80 000 kVA ratings, but the basic principles remain the same.

We are an energy-intensive industry – more specifically a power-intensive industry – and, in fact, have become more power-intensive over the years as some products, e.g. silicon metal, have grown in importance while others, e.g. calcium carbide, have diminished.

Producers have usually located major furnace facilities in areas that afford access to markets and to raw-material supplies – frequently on or near navigable waters – but, almost universally, the need for large blocks of electric power at reasonable cost has dictated the location of the plants. Before World War II, most plants were located at or close to power-generating sites – many were coupled with their own hydroelectric facilities or clustered in locations such as Niagara Falls, where abundant low-cost power led, before 1950, to the development of a major world centre of electrochemical and electrometallurgical industry.

After 1940, the development of economic high-voltage transmission facilities and the expansion of power grids such as those in Norway, Southern Africa, the TVA and BPA regions of the United States, and the Quebec area of Canada, have led to greater flexibility in the choice of

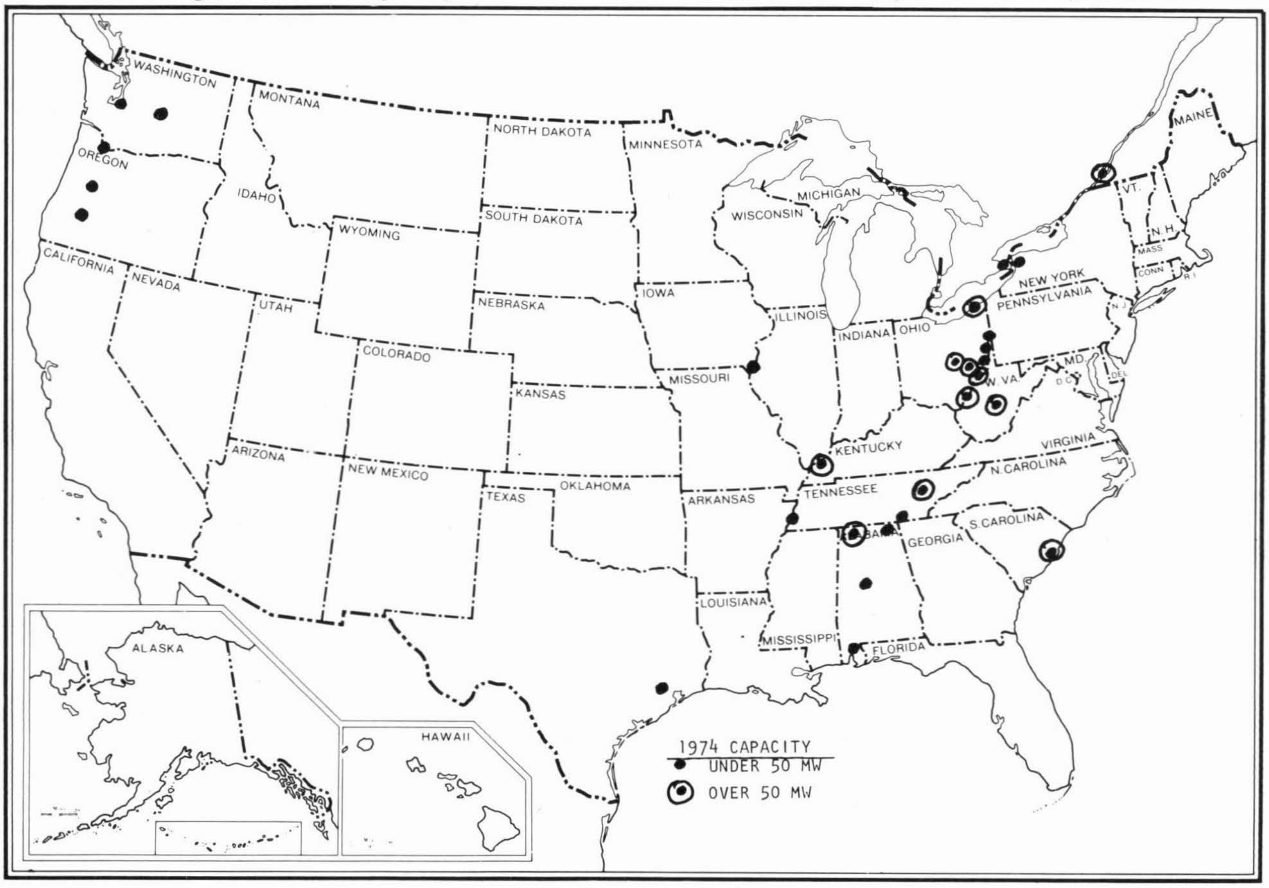

Figure 1
Ferro-alloy plants in the U.S.A. and Canada

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plant location. However, proximity to power-generating facilities or to existing high-voltage transmission facilities continues to offer important economic benefits. Figure 1 shows the locations of existing U.S. ferro-alloy plants and clearly demonstrates the 'drawing power' of low-cost energy.

Union Carbide's 1964 analysis of locations for high-carbon ferrochromium plants in Rhodesia offers an interesting example of the foregoing. In 1962, a study of ferrochromium plant locations singled out Selukwe, the ore source, as offering optimum economics. (We had not seriously considered Que Que, the present location of Union Carbide Rhomet.) The 1964 study involving the possible acquisition of Windsor Alloys at Que Que and stepwise expansion of the facility developed data that, because of high-voltage transmission-grid accessibility at Que Que, indicated that it was the preferred location on a purely economic basis.

Having briefly reviewed the history of the ferro-alloy industry and its interrelationship with energy, we can now turn to the present-day 'energy crisis' conditions and examine the current impact and probable longer-range implications as related to ferro-alloy production.

Europe, the United States, and Japan are all facing the problem of energy shortages and very rapidly increasing prices. In recent months, much has been written about the present and probable future supply situation in the United States. A brief review of some of this information will help to bring U.S. power availability and probable future economics into focus and gives us a pretty good picture of just what most of the industrialized nations will be facing during the years between now and the turn of this century.

Figures 2 and 3 give a picture of present and probable future sources of energy in the United States and clearly indicate a swing away from oil- and gas-generated power toward coal- and nuclear-generated power. Even though the United States has tremendous coal reserves and should be able to attain its goal of energy self-sufficiency by 1985

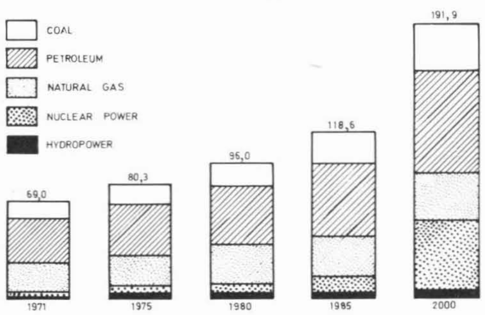

Figure 2
United States energy consumption by source, 1971-2000 (in quadrillion Btu)

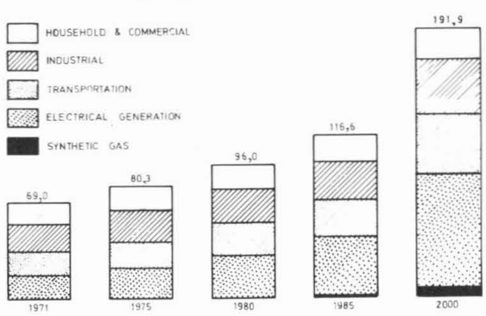

Figure 3
United States energy consumption by sector, 1971-2000 (in quadrillion Btu)

(the stated goal of self-sufficiency by 1980 is considered overly optimistic by most experts), this goal will not be achieved without significant accompanying increases in the price of power.

Figure 4 shows the recent consumer-price trends of a typical coal-based power company in Ohio and demonstrates the present rapid increases following a long period of stability. These increases, and future projected increases, are closely related to a significant loss of productivity in the coal-mining industry (associated with Health and Safety Regulations, which are much more restrictive than those existing before 1970) and a continual tightening of pollution-control standards – most particularly those relating to the discharge of sulphur dioxide.

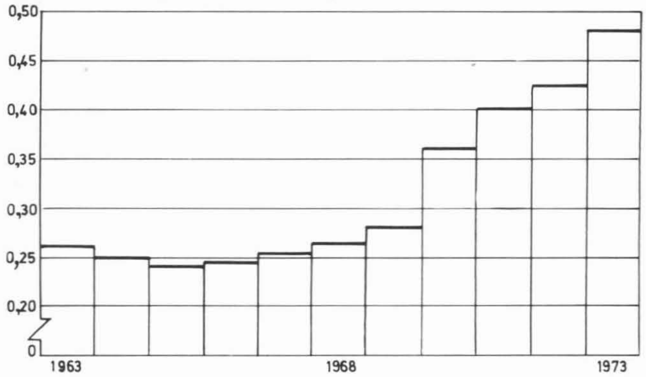

Figure 4
Fuel costs in electric generation (U.S. cents per million Btu)

Selected industrial power prices, typical of those encountered in the ferro-alloy industry, are shown in graphic form in Figure 5. Past rates and projections to 1974 are representative of those actually experienced by ferro-alloy producers in the indicated areas. Projections to 1975 and beyond are of necessity somewhat speculative but represent the best estimates at present available from the specific areas. In general, the United States picture represents a further tightening of standards for SO_2 (with accompanying greater percentages of higher-cost low-sulphur coal in 1975—1977, and with the impact of capital and operating costs of SO_2 scrubbing equipment and greater percentages of nuclear power in 1978 and beyond).

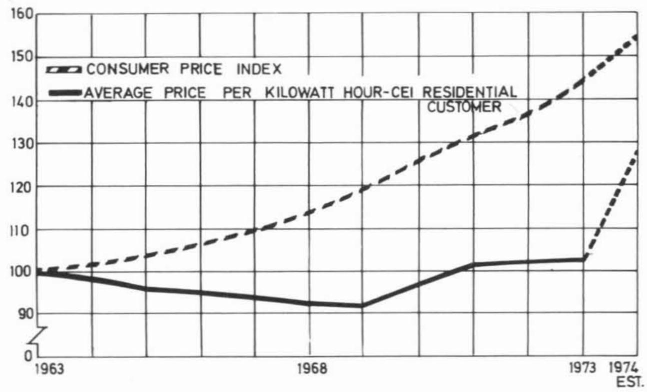

Figure 5
Consumer price index versus average price per kilowatt hour (index 1963 = 100)

For Norway, we see a recently announced increase in grid prices for 1975 and, I should guess, continuing significant increases thereafter – as less economic hydro-potential is developed and greater amounts of thermal and nuclear power enter the picture. Although these trends are correct in pointing the general direction of future power prices – unquestionably much higher than those of the 1960s and early 1970s – and can be used in examining the future course of the ferro-alloy industry, nevertheless political pressures, environmental pressures, and the typical human tendency of overreacting to current happenings when projecting future actions may very well cause a one- or two-year shift in timing. This, however, does not change the longer-term picture. Thus, we are led to the inevitable conclusion that, in a power-intensive industry such as the ferro-alloy industry, the historic pattern of the past (that is, the concentration of major production facilities in areas of abundant, reasonably priced power) will continue into the foreseeable future, and, owing to the very rapid escalation of fuel costs in most industrialized areas, very probably at an accelerated rate.

Obviously, factors other than power will enter the picture and tend to temper it. Pure economic factors such as market location, local availability of raw materials, transportation rates, labour rates, and construction costs will enter the optimization equation along with political factors such as the maintenance of home industry for strategic purposes, tax and tariff barriers or incentives, and stability of government.

However, the sum of all of these economic and political variables leads to the inevitable conclusion that areas that are accessible to ocean shipping and have large blocks of developed but under-utilized energy (such as Iceland, Venezuela, and North America's Pacific Northwest) will attract new ferro-alloy facilities. Additionally, Southern Africa, with its significant hydro resources, abundant low-cost coal reserves, and major chromium and manganese ore deposits, is destined to remain in the forefront of future ferro-alloy facility expansion. Today's approximate industrial power rates of 0,65 U.S. cents represents a relatively small increase over the levels of the early 60s (0,45 to 0,5 U.S. cents), and there is every indication that future rate increases will remain significantly less than those required in other industrialized areas of the world.

Figure 6 shows world areas where major future expansion is most likely to take place.

Pollution-control problems associated with ferro-alloy production have demanded attention since the early 1930s, and many solutions – such as wet scrubbing of exhaust gases from semicovered furnaces – are no longer fully satisfactory in today's environment.

Although 'clean air' pressures are greatest and pollution-control regulations most restrictive in highly industrialized areas of the world, the ferro-alloy industry is moving gradually towards a state of near equality in pollution-control standards on a world-wide basis. Future plans for installations in even the most underdeveloped areas must therefore provide for adequate control of pollutants and must bear the associated burden of capital and operating costs.

This then leads us back to energy – since the approximately 10 per cent additional power required for the operation of most of today's satisfactory pollution-control equipment adds sensitivity to power to the ferro-alloy industry and tends even more to move our planning of future facilities towards large blocks of reasonably priced electricity.

One additional significant trend – associated with the availability of raw materials and energy and with future electric-furnace expansion plans – is the continuing gradual movement away from blast-furnace ferromanganese, with its major problems of coke quality and air pollution, towards more flexible, less restrictive, three-phase electric-furnace production methods.

In summary, the future of our industry looks secure,

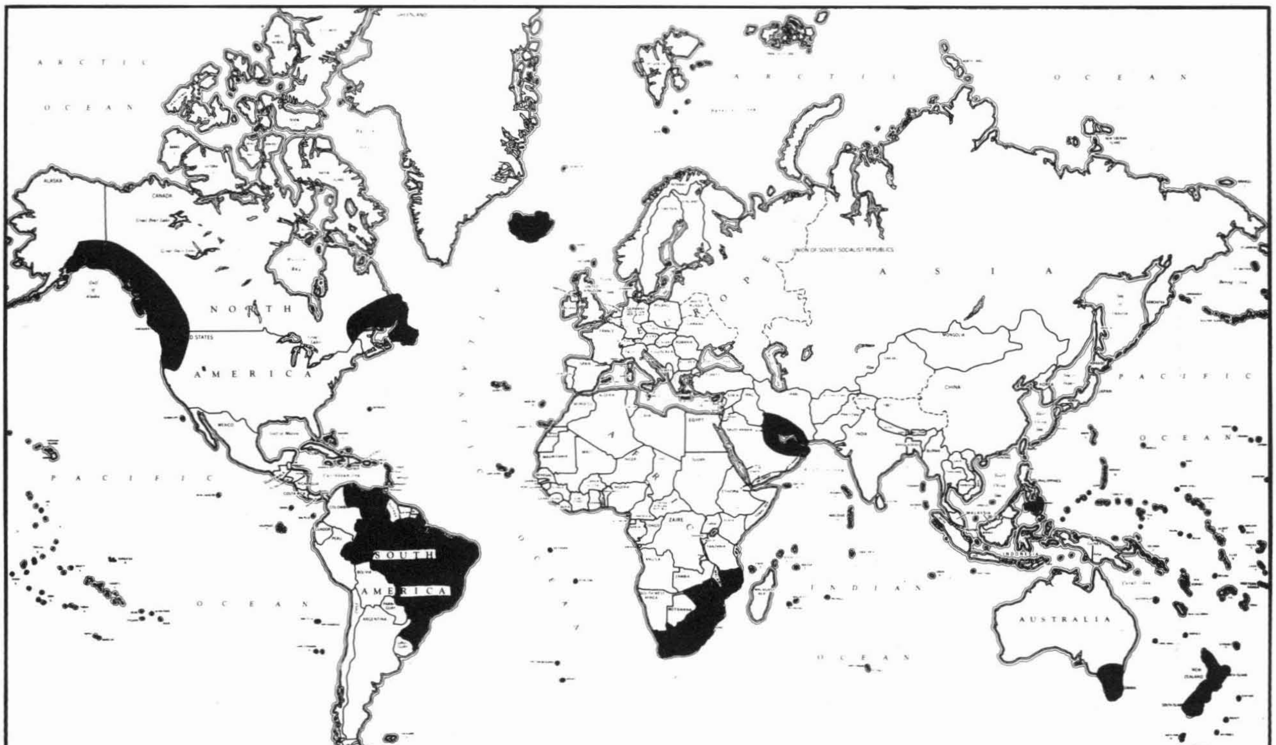

Figure 6

Energy-rich areas with significant potential for expansion or development in the ferro-alloy industry with projected world-wide requirements for ferro-alloys for steel alone pointing toward an additional 450 MW of electric-furnace capacity each year for the next decade; and that capacity will of economic necessity tend to move towards sources of reasonably priced power.

In presenting his paper, **Mr Magruder** said:

Figure 1 of my paper, which gives the location of ferro-alloy plants in North America, shows that they are concentrated mainly near cheap power, the major areas being the Ohio River Valley and the T.V.A. Power Authority area.

Future development in the U.S. is going to be towards nuclear power. As Figure 7 shows, by the year 1985, nuclear power, which was very small in the 1970s, will have grown to be the dominant source of power in the U.S.

Now I should like to comment briefly on Union Carbide's sale of its power facility. We found we were having to contend not only with the pollution-control regulations relating to ferro-alloy furnaces but also with those relating to the fly-ash and SO_2 problems associated with power generation from coal. So, rather than put some 18 million dollars into the upgrading of a 200 MW power station and into the expansion of the coal mine that was feeding it, we decided to sell the power plant and invest the money from the sale in ferro-alloy facilities. The amazing thing was that, for the first year after the sale, the cost of purchased power was half the cost of our self-generated power the previous year. This is merely evidence of the benefits of more modern facilities, better heat rates, and a large network (almost 3000 MW capacity).

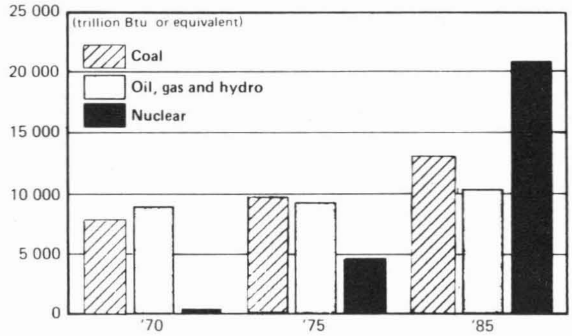

Figure 7

Projected consumption of fuels and hydropower by electric utilities in the U.S.A., showing that nuclear power will become the No. 1 fuel at U.S. power plants (source: U.S. Dept of the Interior)

Prices of power are increasing all over the U.S. and the only place in which there is any indication of continuing low-cost power is the Pacific North West. Elsewhere, there is relatively cheap power in British Columbia and Alaska (hydroelectricity); Venezuela (hydroelectricity, oil, and gas); Quebec, Labrador, and Newfoundland

Table 1

Electric utility industry – installed generating capacity; net generation and thermal equivalent resource inputs, 1971 actual and projected to 2000

Period	Installed generating capacity MW	Load factor	Net generation Billion kWh	Heat rate Btu/kWh	Energy resource inputs Trillion Btu
1971:					
Fuel-burning plants*	302 810	0,50	1 310	10 870	14 240
Nuclear plants†	8 687	0,50	38	10 660	405
Hydropower plants‡	55 898	0,55	266	10 494	2 798
Total	367 395	0,51	1 614	10 807	17 443
1975:					
Fuel-burning plants	350 000	0,50	1 540	10 575	16 280
Nuclear plants	50 000	0,55	240	10 660	2 560
Hydropower plants	80 000	0,50	350	10 200	3 570
Total	480 000	0,51	2 130	10 560	22 410
1980:					
Fuel-burning plants	445 000	0,50	1 950	9 875	19 260
Nuclear plants	120 000	0,60	630	10 660	6 720
Hydropower plants	95 000	0,50	420	9 500	3 990
Total	660 000	0,52	3 000	9 990	29 970
1985:					
Fuel-burning plants	580 000	0,50	2 540	9 575	24 320
Nuclear plants	215 000	0,60	1 130	10 400	11 750
Hydropower plants	120 000	0,45	470	9 200	4 320
Total	915 000	0,52	4 140	9 760	40 390
2000:					
Fuel-burning plants	720 000	0,45	2 840	8 875	25 200
Nuclear plants	960 000	0,65	5 470	9 000	49 230
Hydropower plants	200 000	0,40	700	8 500	5 950
Total	1 880 000	0,58	9 010	8 920	80 380

*Fuel-burning plants include steam, internal-combustion, and gas-turbine plants. Heat rate based on energy inputs to all fuel-burning plants.

†Energy input for nuclear power converted at an average heat rate based on AEC data for projected nuclear plant mixes.

‡Hydropower plants include hydro and pumped storage plants. Converted to theoretical energy inputs on the basis of national average heat rates for fossil-fueled steam-electric plants.

(hydroelectricity); Iceland (hydroelectricity); the Middle East; the Philippines; Australia, especially Tasmania; and New Zealand. Thus, there is still an abundance of power in the world, and I feel certain it will attract future expansion.

I have not yet mentioned Southern Africa, which has power availability at economic prices. The availability of relatively low-cost coal and the tremendous ore reserves make me feel that we are today in the country that will show the development of the greatest amount of ferro-alloy capacity during the next decade or two.

I tried to get a rough picture of the needs of the ferro-alloy industry, and I arrived at 450 MW of ferro-alloy capacity per year over the next decade. I started with U.S. steel production on the assumption that the ferro-alloys supplied to the steel industry of the U.S.A. are typical of those in the rest of the world. It takes 15 kWh to produce the ferro-alloys required for 1 tonne of steel, and this, equated to the projected world growth of 5 per cent for steel, gives us the figure of 450 MW of additional power requirement for the ferro-alloy industry per year.

I believe there is a tremendous period of growth ahead of us, and a bright future. There is no doubt in my mind that future expansion is going to be drawn to the sources of abundant inexpensive energy, and this INFACON is particularly appropriate in that South Africa will probably be in the forefront.

There are two further points I should like to make.

The first concerns the misunderstanding about the role of 50 per cent ferrosilicon in the world, and in the U.S.A. in particular, as opposed to 75 per cent ferrosilicon. From an energy point of view, 50 per cent ferrosilicon gives us silicon units of at least a 10 per cent saving over the silicon units available in 75 per cent ferrosilicon. This is 4,4 kWh per pound of silicon, and to the best of my knowledge good 75 per cent ferrosilicon operations in the world are consuming about 5 kWh per pound of silicon. We in the ferro-alloy industry are doing the steel industry a tremendous service by converting a relatively cheap form of scrap ($60 per tonne) into a relatively pure iron and making it available to iron and steel producers in a form that competes with scrap costing $150 a tonne. Thus, we are conserving energy and are converting relatively cheap scrap into good iron.

My second point concerns the production of manganese. In one of our plants, we have been producing about 2000 tonnes of refined manganese a month by an oxygen-blowing process. It is an energy-conserving process, interestingly enough, in that it uses 1 kWh per pound less power than the conventional silicon—lime—ore melts for refined manganese (this includes the power required for the oxygen in the process). It would be unfair if I did not point out that the manganese recovery is something of a problem. We are probably about two years away from being ready to present a paper on the process.

DISCUSSION

Question from the audience:

How reliable is geothermal power for power-intensive industries, and have geothermal sources been identified?

Mr Magruder:

I do not claim to be an expert in the power industry, my knowledge of geothermal power being quite limited. There are areas in the western U.S.A., and I believe in New Zealand, where development has taken place. As a matter of fact, we have had several people trying to convince us we should put up the money to develop some location on the West Coast, but it will not be a significant contribution to the total power requirements of the U.S. or the world, and is indeed a very minor factor. I think our future is very heavily oriented to nuclear power.

Mr P.E. Streicher:*

What replacement of obsolete facilities do you expect to take place in the next decade?

Mr Magruder:

What I give are merely opinions. I think the type of thing that happened to us in the Niagara Falls area will continue to happen. I have no idea what your plans are for Kookfontein, as one example, but I would imagine that, with additional expansion in the Amcor organization, the next time there is a severe downturn in business you may well think of getting rid of some of your old plant. We do this regularly. I think there is a tendency for the smaller producers of necessity to keep operating, but the large producers in a downturn in business can look at the economics of the more marginal units and decide whether it really pays to shut them down. Turning off does not always take place instantaneously. Even now, we have three furnaces in the U.S. that are idle, and we have found that it is not worthwhile to put them on-line, even with world demand as it is. They are not in very good shape because they have been lying idle for 2 to 5 years. As a pure guess, I would say that, as we continue to build new furnaces, we shall probably lose 10 to 20 per cent of the old ones, or the equivalent of 10 to 20 per cent of the capacity in old units as the new units come in. But this is a pure guess.

*Amcor Management Services (Pty) Ltd, South Africa.